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THE TELEGRAPHIC JOURNAL AND
Electrical Review.
VOL. XX.—No. 493.

THE ELECTRIC LIGHTING ACT.

IN a few days, we believe, the Bill for the amendment of the Electric Lighting Act which has received the assent of the House of Lords, will be submitted to the Commons for first reading, a purely formal proceeding. Whether the Bill will ever progress beyond that stage is, in view of the unsettled state of Parliamentary affairs, extremely problematical. "Ireland blocks the way" in this as in possibly more important matters, and much-needed legislation, involving no questions of party policy, must wait until our leading statesmen have tired of the futile task of endeavouring by half measures either to pacify or to subdue the turbulent inhabitants of Erin. It is a great pity that this should be so. The Crimes Bill may be a measure very necessary for the maintenance of law and order in Ireland, but the need is surely not so urgent but that a few extra hours during the week might be spared for the discussion of more purely domestic legislation. As it is, the debate on Irish questions drags its unnatural length along night after night, wearying Members of Parliament, disgusting the nation at large, and delighting only the Irish party, who are never so well pleased as when useful business is impeded and they pose, to their way of thinking, as the heroes of the time. Railway rates, mines regulation, electric lighting, and a dozen other matters of greater or less importance wait for the attention of the House, but the House is otherwise engaged, and before it finds the necessary leisure to deal seriously with questions which have no smack of party flavour, a dissolution or a change of Government may take place. Of course this would mean beginning over again with every Bill which had not passed into Act of Parliament, no matter what stage short of that point it had reached or how much a matter of general consent its desirability might be. It is a standing evil, and one which has often been protested against, that Bills in this position should be entirely abandoned. Apart from the question of their expediency and usefulness, the great waste of time incurred by the necessity for re-introducing these Bills is a consideration which should have weight with statesmen and lead them to adopt some method whereby Bills partly dealt with and dropped at an intermediate stage in consequence of exigencies arising in connection with the contests between rival politicians should be taken up on the resumption of Parliament at the point where they were left, instead of being regarded, as they are under existing conditions, as so much waste paper. The need for the amendment of the Electric Lighting Act of 1882 has long been practically admitted on all sides, and it will be a serious injury to a deserving enterprise if the disappointments which have hitherto attended the attempts to procure it are now again to be experienced.

DEATH BY ELECTRICITY.

By M. A. D'ARSONVAL.

IN preceding papers* I have shown the physical causes of the dangers of dynamo-electrical machines. At that time I had only small laboratory machines at my disposal. Thanks to the kindness of Prof. Mascart and M. Hippolyte Fontaine, I have recently been able to study the question from a practical point of view, and pursue my experiments at the Collège de France with continuous and alternating current dynamos.

I have taken advantage of these circumstances to make a comparative study of the dangers presented by the different sources of electricity. My researches have been directed successively to the physiological effects of :—

1. A static machine (Holtz with four discs) charging a battery.
2. A battery of 420 volts.
3. Continuous current Gramme machines.
4. Alternating current Gramme machines.
5. Extra current or induction coils, either associated or not with static condensers.

To complete this series I ought to have studied the effects of transformers, which are beginning to enter into the domain of practice, and the effects of which are formidable in a way quite different to those of the preceding machines, but this omission will soon be rectified, thanks to the kindness of M. Picon, chief engineer in the Edison workshops.

With all the sources of electricity enumerated above, death may be caused by placing oneself in certain conditions. This death is accompanied by very variable phenomena and injuries, according to the manner in which it has taken place. In this note I will confine myself simply to showing the practical conclusions to be deduced from my experiments. I found that the very varied effects of electricity on living creatures may be classed into two principal categories which include them all. Electricity causes death in the two following ways :—

I. *By direct action* (the disruptive effects of the discharge acting mechanically so as to distort the tissues).

II. *By reflex or indirect action* (acting on the nervous centres, the irritation of which brings about the infinite variety of effects so thoroughly investigated by M. Brown Séquard, under the names of *inhibition* and *dynamo-génie.*) This simple distinction, resulting from a careful observation of facts, is also of practical value, in that, in the first case, death is certain and definite, whereas, in the second, experiment has shown me that very often the victim may be restored to life by practising artificial respiration immediately after the accident.

Although I cannot here dwell upon this subject, I will briefly mention the dangers of the different electrical sources.

1. The static discharge is only fatal when the *bulbe* is struck directly with well localised discharges, the energy of which corresponded in my experiments to about three kilogrammetres. Under these conditions, the different tissues (nerves, blood, muscles, &c.), when struck singly by the discharge, lose irremediably their physiological properties.

If the discharge has not the force required in order to distort the bulb mechanically, it acts by exciting it and produces the phenomena of respiratory inhibition, inhibition of the heart, sub-pleural ecchymosis, pulmonary emphysema, paralysis, stoppage of circulation, &c., which M. Brown-Séquard has obtained by directly irritating the *bulbaire* region by excitations of various kinds. Contrary to what is generally believed, it is very difficult to kill an animal by shocks. These secondary effects are not, therefore, the work of electricity itself.

2. With the battery of 420 volts, death is only caused by frequent and prolonged interruptions of the current.

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* See *Comptes Rendus* for January 26th and March 9th, 1885, and also *Société de Biologie*, December 20th, 1881.

It is due to the tetanic condition provoked by the current, rather than to the direct action of electricity. Later on I will enter into the effects produced by a battery of 2,000 to 2,500 volts.

3. The continuous current Gramme machine is only dangerous, as I have mentioned in my former paper, from its extra current on breaking. I have ascertained that compound machines or doubly-wound machines give less powerful shocks than machines excited in series or series dynamos. The extra current of a series dynamo, giving 20 ampères and 45 volts, killed a guinea-pig, whereas the extra current of a compound machine, giving 20 ampères and 45 volts, produced no harmful effect. This difference is explained when we consider that the second coil serves as a derivation wire. I succeed in suppressing this extra current by breaking the circuit gradually by means of a simple stoneware tap containing mercury, which serves to cut off the circuit.

4. An alternating Gramme machine only causes death above 120 volts of mean difference of potential.

5. An extra current coil is more dangerous than an induction coil, especially if it is coupled with a condenser.

The danger of an insulated discharge is defined solely by the electrical curve of that discharge. The knowledge of the difference of potential and the average intensity is not sufficient; the duration of the discharge must also generally be taken into account. For the purpose of analysing the physiological effects of electricity, I some time ago designed an apparatus which registers automatically this electrical curve of excitation, a curve of which all the parameters may be made to vary singly and at will. We thus can easily dissociate the effects of the electrical excitant; I will return to this point later.

It is the same with alternating currents, in which we must also take into account the frequency of the reversals. As I cannot dwell upon this now, I will confine myself to saying that under the conditions usually realised in the industrial arts the current kills by reflex action. And I have succeeded, in the majority of cases, in restoring to life animals that have received shocks by subjecting them to artificial respiration.

The practical conclusion to be drawn from this note is that it is necessary in electrical works to be able to practice at a moment's notice artificial respiration upon any one who has received a shock, for by this means there is a good chance of restoring him to life.

The currents employed for industrial purposes up to the present most often kill by stoppage of respiration. Artificial respiration, by preventing asphyxia, enables natural respiration to be re-established.

M. Brown-Séquard, in reference to M. d'Arsonval's communication, offers the following remarks upon the treatment of loss of respiration.

M. d'Arsonval might have said that for several years we have successfully employed at the Collège de France a mode of excitation having great power in bringing back respiration stopped by inhibition. This process is far superior to trans-current cauterisation, which is employed by Faure and other experimentalists. It consists simply in the application of a faradic current to the sides of the larynx on the skin, which is moistened or superficially incised.

We know that in laboratories galvanic shocks are given with a certain amount of success at any point to restore respiration in animals in which that function has been stopped under the influence of chloroform or by other means. We have found in comparative experiments, which remove all doubt, that of all parts of the body that which being galvanised has the greatest power in restoring respiration, is the one we have mentioned. There is a very natural reason why this should be so; by the faradisation of this part the nerves (*les nerfs vagues*) are slightly irritated, which, as all physiologists know, is a cause of respiration, and even sometimes of a considerable increase of respiratory energy.—*Comptes Rendus.*

PRACTICAL ELECTRICAL MEASUREMENT.

By J. SWINBURNE.

(*Continued from page* 397.)

ONE or two forms of apparatus for measuring resistances have been brought out lately for the use of electrical engineers. Messrs. Elliot Brothers make a convenient little bridge and galvanometer combined for testing lightning conductors; this is also made with a set of silver chloride cells in a separate box, and the two boxes can be fastened together into one compact apparatus. The price is £7. It is not usual to give prices of apparatus in technical articles like the present, as it may to some extent give the papers the appearance of a sort of trade advertisement. In some literary journals the fashion is creeping in of giving the prices of the books reviewed, and this is certainly a great advantage to the reader; it is therefore hoped that it may be of some use to give the prices of the electrical apparatus described, as far as possible; in fact, it is really impossible to discuss apparatus apart from its price. For instance, suppose one voltmeter is described which appears free from faults, and another is discussed which is used with a key, because otherwise it would get too hot, or would read wrong, through persistent magnetism. If the prices were not mentioned the reader might naturally suppose the first to be far the best; but it is quite a different matter if one costs £20 and the other £2. Messrs. Davies and Moynihan's combination plug and meter bridge has already been described in this journal, Vol. XIX., p. 55. It consists of an ordinary bridge on one side of the apparatus, and on the other a metre bridge is arranged for measuring low resistances. The galvanometer and cells are separate; the connections are the same whichever way the bridge is to be used, the necessary alterations being made in a very ingenious way by means of the galvanometer and battery keys. The keys, which are connected together, are simply turned to one side or the other, and are held there by a spring. The bridge is very compact, as it only measures $9\frac{1}{2}$ inches by $4\frac{1}{2}$ inches by $5\frac{1}{2}$ inches deep, and the bridge, galvanometer, and cells pack into a slightly larger case. The price is £21. The weak point of such an arrangement is the metre bridge for low resistances. The error due to the resistance of the contacts themselves is too great to admit of accurate work. The metre bridge is also made up by itself, and forms a very compact instrument. This is a modification of the ordinary metre bridge, and is much the same in principle as the metre side of the combination plug and metre bridge, but it is larger, and the cylinder contains the coils belonging to the bridge. The outside of the instrument consists of a cylinder of ebonite, with a double-threaded screw cut in it. In one thread lies a piece of platinum silver wire, which forms the adjustable part of the metre bridge, in the other lies a wire connected with the galvanometer circuit. A ring is tapped to fit the double thread and screws up or down the outside, making contact between the galvanometer and the metre bridge wire. Inside there are coils forming the two sides of the bridge proper, plugs being used to alter the ratios. The coils are ·01, ·1, 1, and 10 ohms, and the instrument is supposed to measure down to ·0005. It need hardly be remarked that the contact and lead errors make it out of the question to measure such resistances as ·0005 ohms even approximately. This little bridge is, however, a very convenient and portable instrument. With its galvanometer it goes into a case $11\frac{1}{2}$ inches by $6\frac{1}{2}$ inches by $4\frac{3}{4}$ inches. It is made by Messrs. Woodhouse and Rawson.

Messrs. Latimer Clark, Muirhead & Co., make a very convenient portable testing apparatus designed by Mr. Blackburn. This has already been illustrated in this Journal, Vol. XIV., page 195, so it need not be very fully described. It consists of a small flat case containing a couple of chloride of silver cells and a bridge and galvanometer. The adjustable part of the bridge is worked by turning a circular plate with rubbing contacts, and the final adjustment is made by means of a wire stretched round it. This admits of very rapid adjustment, a point of great practical importance.

One of the neatest portable arrangements is Cardew's lightning conductor bridge. It is not to be used where great accuracy is required, but for ordinary work, if only a small range is needed, its portability and cheapness, and its readiness of adjustment recommend it. It is made by Messrs. Woodhouse & Rawson. It consists simply of a single wire stretched round the outside of a disc, in a loop, with a radial arm which makes contact with one side of the loop. Terminals are supplied. Fig. 4 is a diagram of the bridge. The battery is connected to C and Z. Tracing the circuit from C it divides at D, from D to F forms one side of the bridge, and the galvanometer connection, G, is attached to F, and that part of the circuit goes on through the resistance, F H, then to Z. On the other side the circuit is from D to K, the galvanometer contact being slid along, and the resistance to be measured is put between E and L. The beauty of Cardew's arrangement is, that it is direct reading, and it will be discussed at some length, because it provides a very simple way of making up a direct reading bridge. If fig. 4 is expanded into the conventional form, it will be found to be a Kirchhoff bridge, as shown in fig. 5. The lettering is here the same as in fig. 4. In order that the instrument shall be direct reading, it is only necessary that M D : M K : : D F : F H; M K can then be graduated to read directly. Thus, suppose D F = ·2 and H F = 2 and M D = ·3 and M K 3 ohms, it is evident that when X = 0 the galvanometer contact is at M. When the contact is at K, the resistance K M + M D = 3·3 ohms, so X must be 33 ohms, as the other sides of the lozenge are as 1 to 10. K is therefore marked 33, and K M is divided into 33 equal parts.

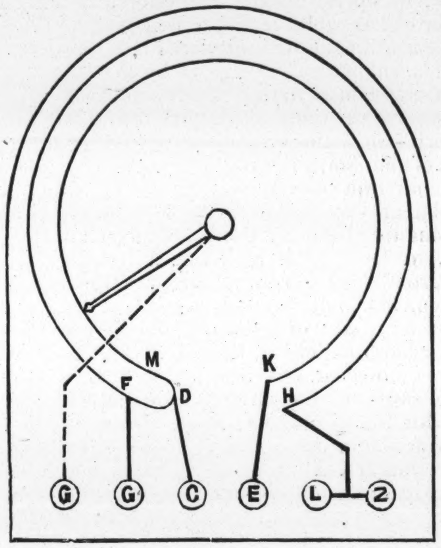


FIG. 4.

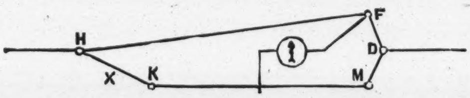


FIG. 5.

The same arrangement may be very convenient for making up a simple bridge on an emergency, or for amateurs. Cardew's arrangement is not so good when stretched out straight, but is easy to make. An evenly divided scale divided into, say, 1,000 parts, is mounted as shown in fig. 6. A uniform wire is stretched over it from the binding screw, E to N, returning by D and F to the other binding screw, H. The calibration of this bridge is easy if another bridge is at hand, or if the scale is not bought ready cut, but can be divided up after the bridge is made. If the scale is bought ready divided and another bridge is not at hand, the bridge can be calibrated from any known resistance that may be obtainable. As the last method demands a tedious process of double adjustment it need not be described. Take first the case that another bridge is at hand to calibrate from, and the scale is already divided as shown.

The points E, K, M, and H are fixed because they are determined by the design of the apparatus. The problem is to find the points, F and D, so that the bridge will read proportionally from M to K and will read in ohms or tenths or hundredths. Suppose it is wanted to read 10 ohms when G is at K, or the 100 mark. The resistances of M K and M E are taken so as to find what number on the scale would be at E if the scale were continued. Call this number 110 for example. Then as the galvanometer must not be deflected when G is at M, E M : M D : : H F : F D; and if G were at E, where the 110 mark would come, the galvanometer should not be deflected if $x = 11$ ohms. Therefore 11 : E M + M D : : H F : F D. From these two equations the positions of F and D are at once determined and measured off. If it is now wanted to make the bridge read from 0 to 100 ohms, two new points are found by similar equations for F and D. In an ordinary bridge the readings are multiplied or divided by altering one side of the bridge only, but in this form both F and D must be altered.

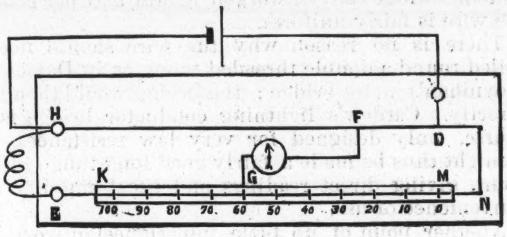


FIG. 6.

Take the second case. Suppose the scale is not yet marked off, and no bridge is at hand; but one coil of known resistance is at hand. Suppose, for example, it is a piece of German silver wire of 7 ohms. The scale is divided very roughly by eye into 10 parts, leaving a little spare room at each end. The 7-ohm coil is put between H and E and a pair of thick wires are also clamped to H and E and arranged so that their ends can be dipped into a mercury cup so that there is practically no resistance between H and E. Of course, it is assumed that the 7-ohm coil has a pair of thick copper wires soldered on, so that errors are not caused by clamping slightly more or less of the wire in H and E. The battery connection, D, is made temporarily at a point selected at random, and the galvanometer slider, G, is put at 0 or M. The other galvanometer wire, F, is then slid till there is no deflection. We have then one of the infinite number of pairs of positions of F and D that give proportional readings. The mercury connection is then opened and the slider moved along the scale till there is no deflection. If G goes off the end of the scale before the galvanometer comes to zero, or if it is too near that end of the scale, M D has been taken too long, and a new position must be taken nearer M. If G comes too near M, M D has been taken too short. A new position for D must be taken, and a new position for F must be found.

This process must be repeated till there is no deflection with the 7 ohms in, when the slider, G, is close to, or at the rough 70 mark. The connections at F and D should then be soldered, and the whole left to cool, as the wires will be warmed by the soldering and by use, and the coil of 7 ohms may also have been heated, and may have a different temperature coefficient. When the normal temperature is reached the mercury contact is made, and the point, M, very carefully found, and marked 0. The point 70 is then found with equal care, and the scale is then divided up into 100 or 1,000 equal parts. For high or low readings the points for the battery and galvanometer connections can only be found by double adjustment.

It is needless to say that it is here assumed that the wire is uniform in resistance between K and M. If the wire is not uniform, it can only be checked from a standard resistance box, 1, 2, 3 ohms, and so on, being inserted at X, the points 10, 20, &c., being thus determined before the scale is cut. The distances between 20 and 30, and so on, can be subdivided into equal parts without appreciable inaccuracy. Platinoid is the best wire, as it alters little with variations of temperature, and is cheap.

Such a bridge as this is not capable of very great accuracy, but is good enough for rough work. For instance, if the scale is 25 inches long, a quarter of an inch stands for one per cent. at the end of the scale, and the bridge can be worked within half per cent. if the wire is fairly uniform.

There is no reason why the wire should not be coiled round a double threaded screw as in Davies and Moynihan's metre bridge; the bridge would then read directly. Cardew's lightning conductor bridge is, of course, only designed for very low resistances, but it might thus be made a fairly good long range instrument, giving direct readings and great rapidity and convenience of use.

Another point of no little importance in workshop bridges, made this way, is that errors due to dirty plugs, or bad sliding contacts, do not come in, as the only sliding contact is in the galvanometer contact where a variable resistance does not matter.

(*To be continued.*)

A NEW METHOD OF REGULATION IN THREE-WIRE DISTRIBUTION.

IN the usual method of distribution on the three-wire system, the current furnished by the dynamo passes to the main and then through a group of lamps to a connecting wire, from which it passes through another group of lamps to the other or return main, and thence to the dynamo. Such a system ordinarily requires that the energy of current or number of lamps be equal for each multiple arc group; that is, that the groups be "balanced;" but where this is not the case, a compensation may be secured by the employment of resistances placed in branch circuit around the group containing the fewest lamps, or in which the smallest current is needed.

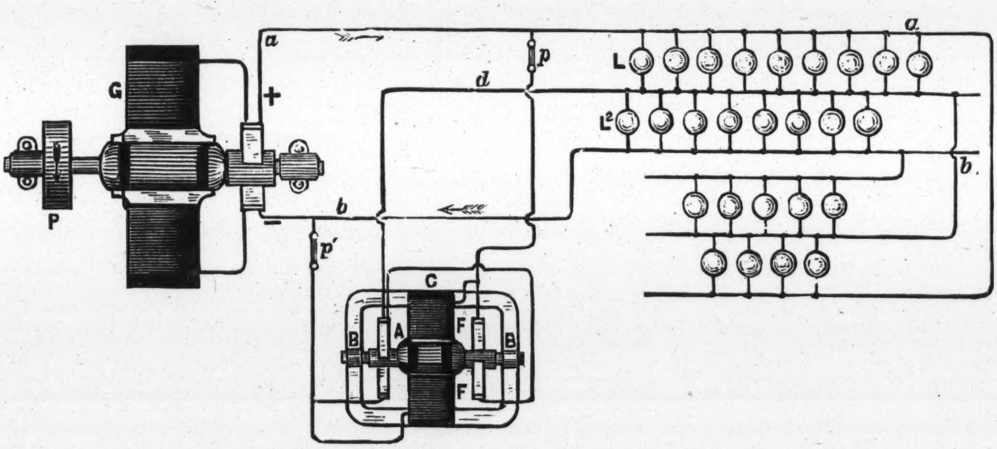
In a new arrangement designed by Prof. Elihu Thomson, as set out in the *Electrical World*, to effect proper regulation of the current in each group of lamps, the compensation is rendered automatic, and at the same time a transfer of energy is made from the parts of the circuit where it would otherwise be in excess to those parts which require more.

Prof. Thomson accomplishes this by combining with the mains of a multiple arc series, or three-wire system, a converter which permits of the extinguishing of lamps in any multiple arc group at will, relying upon the compensating apparatus to effect a proper balance.

The manner in which this is accomplished is illustrated in the accompanying diagram. In this, G represents the generating dynamo, which maintains a fairly constant difference of potential between the mains, *a* and *b*. The potential is sufficient to work two multiple arc sets of lamps in series, as indicated at L, L^2. The intermediate wire, *d*, unites the two sets.

Now, in operating such a system, so long as the number of lamps in L and L^2 be equal, or the current in both is alike, no difficulty will be experienced; but should a change take place, as by the extinction of a part of the lamps in the set, L^2, an excess of current will traverse the remaining lamps of the set, increasing their brilliancy, and tending also to decrease the brilliancy of the lamps in group or set L.

Any attempt to adjust matters by changing the potential at the generator, G, is without avail. To overcome the difficulty Prof. Thomson attaches to the mains, *a*, *b*, *d*, what he terms a "compensator" or "converter," for current energy. One of his best arrangements is illustrated at C in the engraving. It consists of a sort of dynamo generator or motor, or rather a combination of the two. The field-magnets, F, F, are connected, one terminal to *a* and the other to *b*, as a shunt to the circuit or branch from *a* to *b* of rather high resistance, so as to demand but a very small fraction of the current.



The armature, A, is wound with a double winding or two separate and insulated sets of coils, which are, however, the counterparts of each other in electromotive energy. The armature windings or sets of coils are each provided with a separate commutator and brushes, shown to the right and left of the armature, A. The armature windings are made of quite low resistance and of such length of wire that they will give, respectively, when revolving in the field, F, F, at a high speed, an electromotive force equal to that which normally exists between *a* and *d* and between *d* and *b*., *i.e.*, the voltage of the lamps used in L and L^2.

The connections are made as shown. If *a* be the positive wire of G, then *b* will be negative, and *d* nearly neutral, when the lamps in L and L^2 are equal in number. A wire is carried from *a*, through a fusible plug, *p*, to one of the brushes of the compensator, C, which brush, when the armature, A, is revolved, will receive a counter-electromotive force from the commutator segments, tending to oppose the potential of *a*. The opposite brush is connected to *d*. On the other side, as shown, and at the other commutator a brush is connected to *b* in like manner, so that when revolved the armature, A, will give a counter force to oppose the potential of *b*. The opposite (upper) brush is connected to d. The apparatus and circuits thus arranged will give the following results :

Assuming the demand for current in L and L^2 the same, the potential between a and d will be equal to that existing between d and b. The armature, A, will receive current at both commutators, tending to short-circuit from a to d and from d to b through each set of coils on it. The result of current passing in A, if the brushes on the commutator be set on the neutral line, will be to drive A as a motor without load, and its speed of rotation will continually increase until the counter potentials developed in its coils almost neutralise the potentials between a and d and d and b, so that little current flows in A, and only enough to keep up the speed of A. Now let some of the lamps, L, be cut off. The potential between a and d will at once rise and that between d and b will fall, because the resistances are now no longer evenly distributed from a to b. As the resistances of the windings on A are quite low, more current will now pass from a to d through one winding of the compensator armature, A, and it will run faster than before. The device will now act as a generator to give current back to the circuit between d and b by the other winding ; or, in other words, it becomes a motor-generator running by the higher potential to feed the main having the lower, and the action will occur with either winding on A, according as the higher potential exists between a and d or between d and b, the higher potential sending current through the motor-generator, C, and inducing current in the other armature-winding, which is fed out to raise the lower potential. It is essential that the resistances of the windings on A be so low as to be negligible, and that their opposition to passage of current under normal conditions be due to counter-electromotive force solely.

As will be seen, under the conditions outlined above, the apparatus acts as a converter for turning or converting the electric energy or potential existing between one pair of mains into electric energy or potential between another pair, so as to effect an equalisation.

As it is usually only necessary to provide for a partial extinction of lamps in either group, the compensator, C, is small compared with the generator, G, and, furthermore, its effectiveness can be enhanced by constructing it to run at very high speeds, as it requires no belts and there is no strain on its bearings.

ON A NEW METHOD OF EXCITING THE VOLTAIC ARC, WITHOUT PREVIOUS CONTACT OF THE TWO ELECTRODES.[*]

By M. G. MANEUVRIER.

WE know that it is not possible, under ordinary conditions, to light a voltaic arc between any two electrodes which are separated by even the smallest possible space. They must previously be brought into contact, so as to ensure the passage of the electric current, and then gradually separated up to a maximum distance, which is always more or less short, and which depends principally on the available electromotive force.

This double necessity of previous contact of the electrodes and of their being kept within a fixed distance, greatly complicates the use of the voltaic arc and has considerably limited its scientific applications. Attempts have been made to obviate this drawback in two ways.

The two electrodes (for instance, two points of Carrè carbons) being connected to the two poles of the current generating apparatus, the flame of a candle is interposed between them ; and after a little while, the arc shoots out. The more smoky and less oxydising the flame is, the better does the experiment succeed. Another way is to cause to pass between the two points, either the discharges of a powerful electro-static machine, or better still, the series of sparks from a Ruhmkorff coil : the voltaic arc is lighted at the end of a certain time, which is shorter according as the sparks are longer and more reiterated.

But these two methods, besides not being very practicable, are limited in their application to very short lengths of arc. Thus, with the apparatus which I employ,[*] I have not been able to effect lighting by the flame beyond 7 millimetres. The maximum distance was yet shorter with the second process : I never exceeded 3 millimetres, although using the discharges of a bobbin of the largest type, the striking distance of which amounted to as much as 10 centimetres. Now, I can, on the contrary, produce the voltaic arc spontaneously, at increasing distances of 5, 10, 15, 20, 25, and 30 millimetres, by my new method of lighting, which does not necessitate the employment of a flame, or a condenser, or any kind of mechanism. I will now describe it.

I enclose the two electrodes, placed opposite one another, in a glass globe hermetically closed, and furnished with a tubing with a tap having three channels, by which I can, at will, exhaust the air inside, or introduce the outer air. The capacity of the closed globe depends on the diameter of the electrodes. In my experiments it varied from that of a large electrical egg, for carbons of 6 millimetres, to that of an Edison lamp, for carbons of 1 millimetre. The two electrodes being connected by platinum wires soldered into the glass, with a source of alternating currents, I rarefy the air of the globe until a violet effulgence, similar to that of the electrical egg is produced. I then turn the tap so as to admit some particles of air, we then see the long, pale, effulgence suddenly become collected together between the points, under the influence of the sudden increase of pressure, and become instantaneously transformed into a voltaic arc of dazzling whiteness. The experiment is very fine, very neat, and most easily performed.

The degree of rarefaction to which the inner atmosphere must be brought in order to produce the effulgence depends a little on the distance between the points, but much more on the electromotive force of the source. I have never had occasion, in my experiments, to push the vacuum beyond from 5 to 6 mm. of mercury, even at the beginning, when the carbons are cold.[†] As to the increase of pressure necessary in order to transform the effulgence into an arc, it must not be too great, as it would then cause total extinction and the experiment would have to be commenced afresh ; but it may vary between pretty considerable limits. The final pressure, after the transformation, may extend from 30 to 150 mm. This enables the experiment of lighting to be repeated with great facility and with the certainty of success. The manipulation is most simple as it consists in first giving a half-turn to the right, so as to produce a vacuum in the globe, and then a quarter of a turn to the left, in order to admit a little air ; occupying only a few seconds.

Out of the methods of exciting the arc without contact which I have mentioned, only the last really deserves the name ; the two others are methods of lighting with contact, more or less disguised. In fact, in lighting with the candle we may clearly observe the formation at the two points, as they become incandescent, of excrescences consisting of particles of carbon, which keep increasing in size and approaching one another; the arc is formed at the moment that the two deposits meet at some point. In lighting by discharges the sparks give rise between the two electrodes to a sort of current of particles of carbon, which become denser and denser, until at last they close the circuit, and then being rendered incandescent by the passage of the current, constitute the voltaic arc.

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[*] This method has been put into practice at the laboratory for researches (physics) at the Sorbonne.

[*] This is a Gramme machine, with alternating currents, in which one circuit out of four works alone, and can give from 400 to 500 volts at the terminals. I easily measure this difference o potentials at each moment, by connecting the terminals to Branly electrometer, rendered aperiodic by means of Messr Curie and Ledeboer's arrangement, and graduated by M. Joubert method.

[†] I say at the beginning, for if the experiment is repeated afte the carbons and the inner air have been warmed, by even a ver short lighting previously, the conductivity is so much increase that the effulgence easily reappears under a pressure of 50 mm.

The very nature of the phenomenon, in these two cases, shows that it may easily be interrupted by any circumstances opposing this parasitic communication between the two points, particularly by the increase of the distance between them. But it is clear on the contrary, that with my method the lighting of the arc may theoretically be effected with any distance between the electrodes, provided that the rarefaction is carried sufficiently far, and, consequently, the electrical conductivity of the gaseous atmosphere introduced.

In conclusion, I will add that when once the lighting is effected we have only to close the globe in order to have a voltaic arc in a closed vessel, sheltered from the air and from combustion. This arc possesses remarkable steadiness, both as regards the intensity and quality of the light. The consumption is thus very trifling, as it proceeds merely from the wearing down of the carbons, and the projection of their incandescent particles. I will not dwell upon the practical applications that might be made of this apparatus to electric lighting as this point has no scientific interest. I will only remark that this method does away with all disturbances in the burning of the arc arising from combustion and from the continuous increase of length; they are reduced to a minimum, that is to say, they are limited to those arising from the more or less irregular rendering from the electrical source. We thus arrive at better conditions of stability and duration for studying the physical characteristics of the voltaic arc, for instance, its electromotive force and resistance. This experimental apparatus may therefore render good service to those physicists that occupy themselves with these questions.

AN EIGHT-LIGHT DYNAMO.

UNFORTUNATELY for the tyro in electrical matters, no rule or set of rules exists in the literature of dynamo-electric machinery which would enable him, with entire confidence of success, to plan a new form of dynamo, or even to attempt to construct any one of the well-known forms. The available information generally fails in some minor details, thus, in some degree, obscuring the whole subject, and awakening doubts as to the best course to pursue. One might follow such information as closely as possible, and proceed so far as to make an operative machine, writes Geo. M. Hopkins in the *Scientific American*, and yet it might happen that no current could be evoked from it, simply for the want of specific knowledge as to how to secure the first increment of magnetism necessary for starting the inductive process.

The writer knows a case in point where good workmanship, proper proportions, and correct connections failed of giving any result whatever. Naturally, rewinding was resorted to, but to no purpose. Other experiments were tried, with no better results. But, finally, acting upon a hint given by a builder of dynamos, the maker of the machine was out of his difficulty almost in an instant.

It is not the purpose of the present paper to treat on dynamos in general, but to give, as fully as possible, specific information as to the construction of a small dynamo-electric machine capable of supplying a current for eight 16-candle-power incandescent 50 volt lamps, or a larger number of smaller incandescent lamps of suitable resistance, or an arc lamp of ordinary power. The armature speed is 2,200 revolutions per minute, and the machine running normally requires one horse-power to drive it. The machine weighs 130 lbs., and occupies a floor space of 8 × 18 inches.

The dimensions of the machine are tabulated below:—

Height of field magnet	13	inches.
Length of field magnet waist	$6\frac{7}{8}$	„
Width of field magnet waist	$5\frac{3}{8}$	„
Thickness of field magnet waist	$1\frac{5}{8}$	„
Depth of polar extremities from waist to base...	$4\frac{1}{2}$	„
Width of polar extremities	$6\frac{3}{4}$	„
Thickness of polar extremities	3	„
Diameter of bore of polar extremities	$3\frac{5}{8}$	„
Thickness of yoke...	$1\frac{7}{8}$	„
Diameter of bolts passing through the yoke ...	$\frac{5}{8}$	„
Length of armature shaft	18	„
Diameter of armature shaft	$\frac{5}{8}$	„
Diameter of armature shaft bearings	$\frac{1}{2}$	„
Length of parallel faces of armature	$6\frac{3}{4}$	„
Diameter of iron rings of armature core, outside	3	„
Diameter of rings of armature core, inside ...	$1\frac{7}{8}$	„
Thickness of rings...	$\frac{5}{32}$	„
Number of iron rings on armature core ...	39	
Diameter of wooden armature core	$1\frac{7}{8}$	„
Length of wooden armature	$6\frac{5}{8}$	„
Length of armature core...	$6\frac{5}{8}$	„
Number of divisions of the armature core ...	24	
Number of divisions of the commutator cylinder	24	
Length of commutator cylinder...	2	„
Width of brushes...	$\frac{13}{16}$	„
Size of wire on armature, No. 20 Am. W. G....	0·027	in diam.
Length (approximate) of wire in each armature coil*	25	feet.
Number of convolutions in each layer... ...	8	
Number of convolutions in each coil	16	
Number of layers in each coil	2	
Number of coils in each space of the armature	2	
External diameter of armature...	$3\frac{3}{8}$	inches.
Weight of wire on armature	$2\frac{1}{4}$	pounds.
Diameter of pulley on armature shaft... ...	$3\frac{1}{2}$	inches.
Width of pulley on armature shaft	$2\frac{1}{2}$	„
Width of driving belt	2	„
Size of wire on field magnet, No. 18 Am. W. G.	0·033	in. diam.
Number of parallel wires on each leg of field magnet	4	
Number of layers of wire on each leg of field magnet	8	
Number of layers for each wire...	2	
Weight of wire on field magnet...	17	pounds.

The field magnet is made of two like parts of soft, gray cast iron, joined at the centre of the yoke, and bound together by two bolts, as shown in fig. 1. The adjoining surfaces of the yoke are accurately faced, so that when clamped together, the connected halves of the magnet will be practically the same as if made integrally.

The bore of the polar extremities of the magnet is $3\frac{5}{8}$ inches in diameter, and the sides of the magnet around the bore are faced in the latter to form a true support for the bronze yokes supporting the ends of the armature shaft. These yokes are bored to receive the armature shaft, and faced on the lathe upon the surfaces abutting against the sides of the magnet. The yokes are secured in their places on the magnet with their centres coincident with the axis of the bore of the magnet.

The armature shaft is fitted so as to revolve freely on its bearings, and there is a clearance between the periphery of the armature and the magnet of about one-eighth of an inch.

Upon the portion of the armature shaft lying between the poles of the field magnet is placed the cylinder, of seasoned hard wood, of the size above given. Upon this wooden cylinder are placed the thirty-nine iron rings or washers, with intervening paper rings of the same size and about $\frac{1}{32}$nd of an inch thick. The iron rings are drilled at diametrically opposite points to receive the brass rods by which the entire series is held together. The management of the parts of the core of the armature is shown in fig. 2, in which some of the iron rings have been separated to more clearly illustrate the construction.

The series of iron rings is secured to the wooden cylinder and the shaft by two pins passing through the rings, the wooden cylinder, and the shaft.

The edges of the round rings are rounded, to prevent

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* This quantity varies a few inches with the different coils.

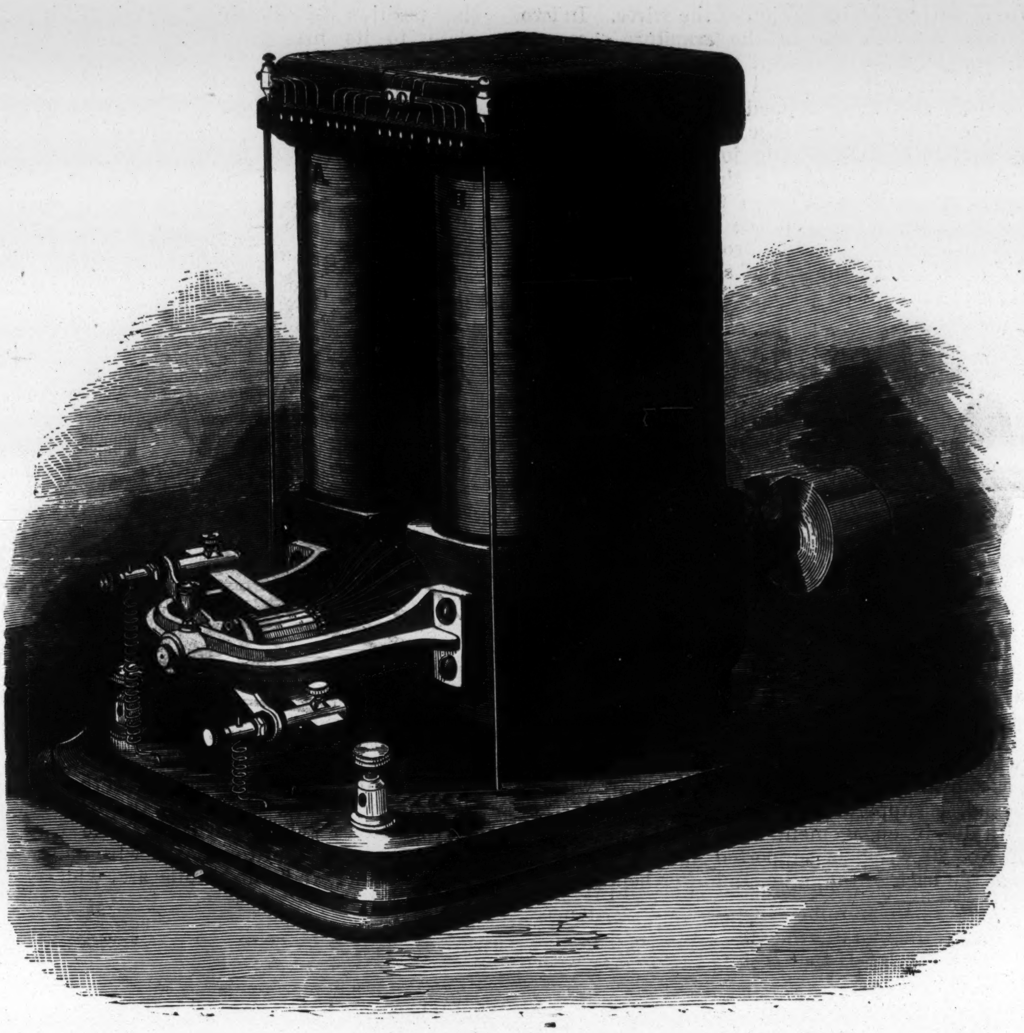

FIG. 1.—EIGHT-LIGHT DYNAMO.

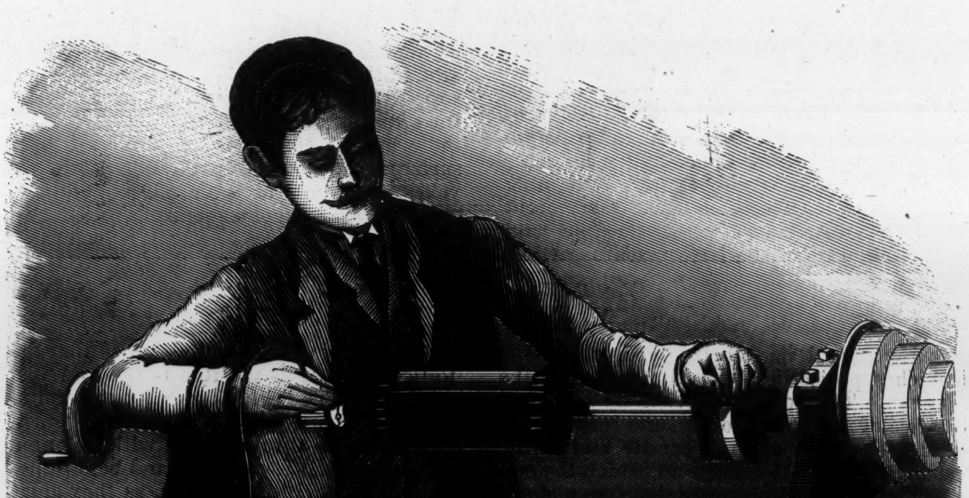

FIG. 3.—METHOD OF WINDING.

them from cutting the insulation of the wires. In two of the rings at each end of the armature core, are formed twenty-four equi-distant radial slots, *b* (fig. 3), one-eighth of an inch deep and $\frac{1}{16}$th of an inch wide. The armature core thus formed is covered over its entire surface with adhesive tape, such as is commonly used by wire men for covering joints in conductors. The tape is wound spirally on the periphery of the core, and is arranged radially on the end of the core. It is also wound spirally upon the shaft one inch and three-eighths in each direction from the ends of the armature core. Into the radial slots, *b*, are driven small wedges, *a*, of hard rubber, which are allowed to project $\frac{3}{16}$ths of an inch beyond the periphery of the core.

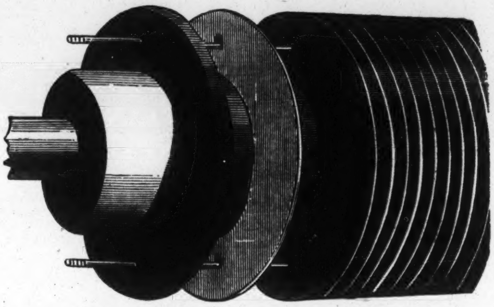

FIG. 2.—PARTS OF ARMATURE COIL.

The winding of the armature is most readily done in a lathe, as shown in fig. 3. The armature shaft with a dog attached, is supported between the centres of the lathe, with dog in engagement with the face plate. A spool of No. 20 wire* is supported in a convenient position at the back of the lathe, and after bending the end of the wire around one of the wedges, leaving about four inches projecting beyond the wedge, the winding is begun. The wire is carried by one hand along the surface of the armature core and through the space between two wedges at the opposite end of the core, corresponding with the space in which the coil was started. The other hand grasps the face plate of the lathe, and as the wire is carried across the end of the armature core, the face plate is dexterously turned through a half revolution, bringing the opposite side of the core uppermost. The wire is then laid between the two pairs of wedges diametrically opposite those embracing the wire on the other side of the armature. The wire is carried across the commutator end of the armature core, and the armature is returned to the position of starting by returnining the face plate to its first position, and the wire is laid alongside of the portion first laid on. The wire is carried lengthwise around the armature in this manner until eight parallel convolutions have been laid on. This layer of wire will extend across the space between two of the wedges. In fig. 4, the inner layer, B, is represented as being raised from the core, to more clearly show the position of the wire on the armature, and the inner and outer coils are widely separated; but it will of course be understood that these wires are to lie as closely as possible to the core in the working machine. The beginning or inner terminal, E, of the coil, B, is represented in black. In practice, this end of the wire is always coated with coloured varnish as soon as the coil is complete, and before the two ends of the coil are twisted together, as they always are temporarily, for convenience in winding, so that there cannot be a mistake as to which are the inner and outer ends of each coil.

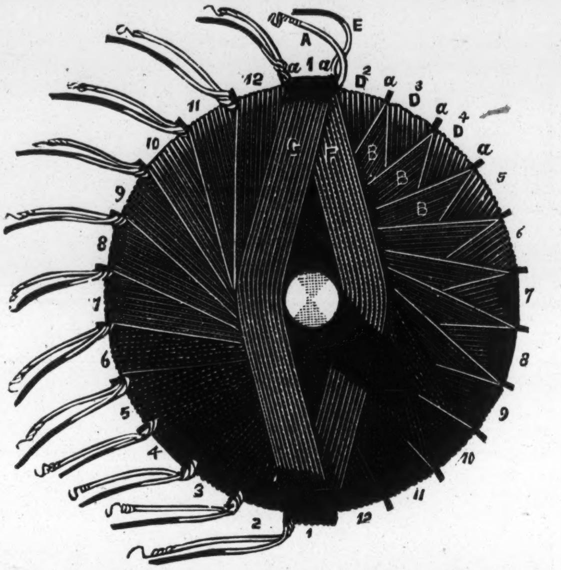

FIG. 5.—STARTING THE OUTER SERIES OF COILS.

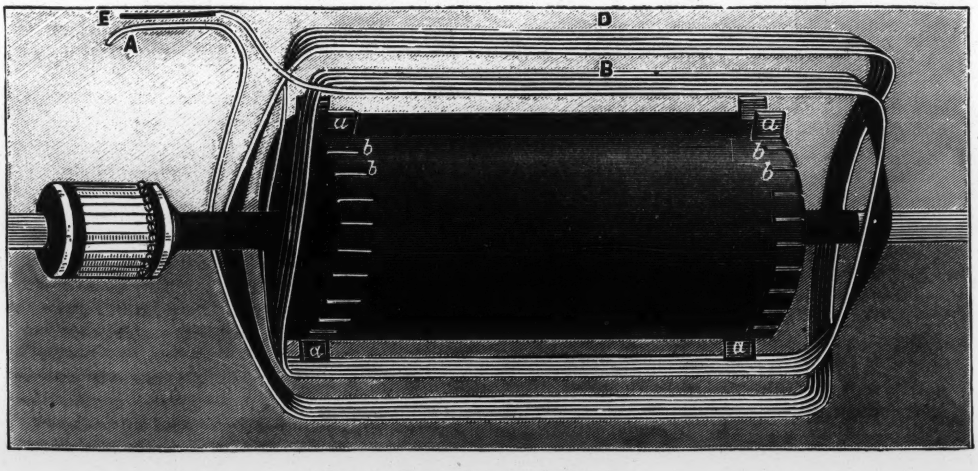

FIG. 4.—FIRST COIL ON ARMATURE.

After winding the inner layer of the first coil, the winding is continued, forming the outer layer, D, on top of the inner layer, by winding in the same direction, but returning by the successive coils of the second layer toward the point of starting. When the outer layer is complete, the wire is cut, leaving a projecting end about four inches long. The coloured or inner end of the wire is now twisted with the outer or un-coloured end. In this manner, the first coil is placed in the spaces, 1, 1, of the armature. It will be observed by reference to figs. 4 and 5 that the two halves of each coil are arranged across the end of the armature on opposite sides of the shaft. This secures a compact end and a minimum amount of dead wire.

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* The wire used is the best cotton covered magnet wire.

After placing one coil in spaces 1, 1, in the manner described, spaces 2, 2, are filled in the same way, then 3, 3, and so on, until 12 coils are wound upon the core. These coils half fill all of the pairs of spaces 1, 1, 2, 2, 3, 3, &c., to 12, 12, with terminals, A, E, projecting from each space around one-half of the periphery of the commutator end of the armature, the end of the armature presenting an appearance which would be indicated by fig. 5, if the coils, G, F, were omitted. When the armature is half filled, the winding is continued in exactly the same manner and in the same direction as before, forming a coil of two layers, F, G, in spaces 1, 1, on top of the first coil, B, D, leaving projecting terminals, as in the case of the first series of coils. Then a similar coil is formed on top of the coil in spaces 2, 2, and so on, until each pair of spaces contains two coils, one superposed on the other, every coil being formed of two layers of wire, with eight strands in each layer.

It is advisable, before winding the outer series of coils, to bind the inner series close to the core by a winding of stout linen thread at three equidistant points in the length of the armature. As a guard against the possibility of short circuiting, the terminals of each coil, where they are in contact with each other or with other portions of the wire, should be provided with an extra wrapping of cotton. The armature thus constructed is known as the Siemens or Hefner-Alteneck armature.

EXPERIMENTS WITH GAS MOTORS.

IN a paper by MM. Salanson and Debucy read before the French Gas Association, the authors come to the following conclusions, as the result of their experiments :—

As we increase the percentage of gas in the cylinder we find first no explosion, then explosion and a gradually increasing amount of work done with a maximum at 16 or 18 per cent. of gas, then a falling off in the work done, and ultimately no explosion. On the other hand, the consumption of gas per horse-power per hour increases constantly with the percentage of gas, and this the more so the more the gas mixture is compressed. Therefore, use the weakest mixture convenient, and attend to this rule more diligently in compression engines.

What is the least proportion of gas which will make an explosive mixture ? If the gas and air have been carefully mixed, the gas must be 8 per cent. ; if the gas be rushed in and ignited, the average percentage may be as low as six. From this it would appear that the richest portions ignite and set fire to the poorer, which would not have ignited directly ; and that there *is* a want of homogeneity in such a mixture so produced. The inrush of streams of gas would produce, not homogeneity, but whirlpools.

As to residues of the previous combustion : these cause variations in the speed of propagation of flame, and irregularities in the distribution of the gaseous mixture ; and the residues in the cylinder produce irregularities in the combustion, and shocks, visible in the diagrams. Hence the access of the gases should be such as to prevent whirlpools.

The ignition should start from an origin of a perceptible size.

As to the influence of the walls : the walls should be warm, and therefore the gaseous mixture should be heated beforehand and compressed ; and conversely, in order to keep down the temperature of ignition, the same rule as was given above applies—namely, that the mixture should be weak.

The phenomena in the cylinder lie between detonation and combustion, but are nearer to detonation. Nitro-glycerine, &c., explode most forcibly when they are warm, hermetically enclosed, and subjected to compression. In a closed cylinder flame will explode nitroglycerine, while in the open air it would not do so. This is analogous to Mallard and Le Châtelier's experiment. They found that a long tube of explosive gas mixture would explode if kindled at the closed, but might merely ignite if kindled at the open end. This would explain the weaker portions of a non-homogeneous mixture being explosively ignited on the combustion of the richer portions. In much the same way black powder produces detonating and shattering effects, as Drinker found, if it be ignited with the aid of a small charge of dynamite.

VERNON HARCOURT'S PENTANE STANDARD LAMP.

WE show on p. 422 an engraving of the latest form of the Pentane Standard lamp, the invention of Mr. A. Vernon Harcourt, of Oxford, and made by the Woodhouse and Rawson Electric Manufacturing Company, Limited, of Hammersmith.

The lamp is the portable form of the Standard which has been unanimously recommended by the Photometric Committee of 1881, and that appointed by the British Association in 1886.

The value of pentane as a standard combustible mixed with air was thoroughly established by the experiments of the 1881 committee, and Mr. Harcourt's experimental data with regard to the composition of the liquid have never been called in question.

But though the reliability of the pentane standard of light has been firmly established, and, in fact, is the standard by which the daily tests of the Gas Referee's Office are made, yet the apparatus necessary, namely, a gas holder, governor, and meter, have led Mr. Harcourt to design a lamp which should be complete in itself, requiring no governor or artificial pressure of gas or other combustible, but only the force of gravity acting upon the very easily produced vapour of pentane.

The pentane lamp, as shown here, is the outcome of a very large number of experiments to produce a self-contained standard of light in a thoroughly practical and reliable form. A true standard must be designed so as to rely upon a few simple measurements. In the above lamp these are three in number, viz. :—The height of head of air gas ; the size of the opening in the burner ; the size of the opening in the tap.

These are all capable of verification within exceedingly close limits.

In the upper part of the lamp will be seen a chamber into which pentane is admitted in the liquid state. It there becomes volatilised and mixes with the air-forming strata of least density above and gradually increasing density below. Inside the chamber is an open pipe down which the mixed air and gas flow (becoming more intimately mixed as they go) and passing through the tap at the lower bend find their way to the opening of the burner where they are consumed.

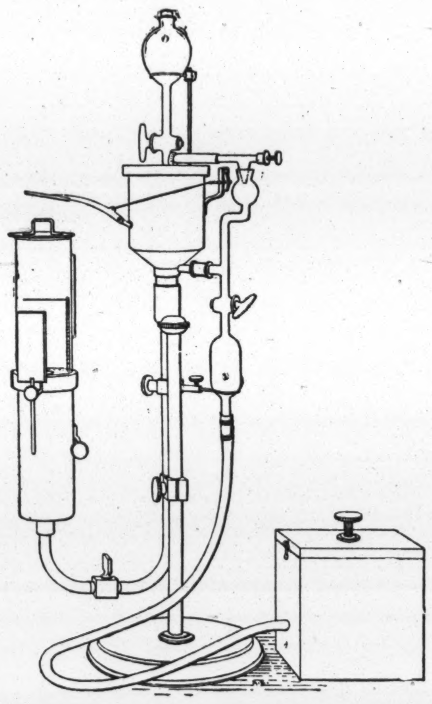
Now Mr. Harcourt has shown that when pentane and air are mixed in certain definite proportions then the light given by a flame of 2½ inches in height is an invariable quantity (subject only to correction for barometrical pressure) and equal to the mean value of the Parliamentary standard candle. If, therefore, the dimensions of the lamp are such as to cause only exactly the right mixture of air and vapour to produce a flame of 2½ inches, and all others to give either too high or too low a flame, then when the flame is exactly 2½ inches high, the light emitted will always be the same and so becomes a true standard of light. The necessary dimensions are comprised in the three measurements given above.

When these are accurately gauged then the correct mixture is the only one which will produce a flame of $2\frac{1}{2}$ inches, and consequently of definite illuminating value.

But to produce this steadily and continuously and to have it completely under control, requires the addition of a certain apparatus which will easily be understood from the sketch.

1. The feed of the lamp must be regular and at the proper rate; it is, therefore, produced by gravity, the pentane flowing down from the bulb reservoir on the top of the lamp, and dropping into a glass tube, by which it is conveyed to the mixing chamber. The rate of drop is regulated by a special device, consisting of a piece of thermometer tubing, which can be closed for more or less of its length by a platinum wire attached to a screw, By this method the rate of drop can be easily regulated to a nicety, and, when once the right rate is found, it is not necessary to alter it, and the lamp can be started with the certainty that the pentane will be supplied at the correct rate for the maintenance of a $2\frac{1}{2}$-inch flame.

The tap attached to the reservoir bulb has only to be opened or closed to start or stop the feed. But as the height of the vapour in the mixing chamber will depend upon the temperature of the room in which the lamp is working, it is necessary to have the level of the pentane in the chamber under control.



This is effected in a perfect manner by the action of the screw handle, seen above the square box, connected with the lamp by rubber tubing. Inside the box is a rubber ball containing water, which, by the action of the screw, is forced up into the bulb below the horizontal tube leading into the mixing chamber. If the flame is too low more water is forced into the bulb, the height of the liquid in the chamber is raised, a richer mixture flows down the tube, and the flame consequently rises. If the flame is too high, a turn of the screw lowers the level, and the flame diminishes. In this way a flame of any required height can be immediately produced.

When, therefore, a constant temperature has been attained in the chamber, and the right level has been found for a required height of flame, the feed of the lamp maintains its level at a constant height, and the flame remains perfectly constant.

As the temperature of the room might be such as to produce volatisation of the pentane too slowly, and in order to render the temperature inside the mixing chamber independent of the surrounding atmosphere, a copper disc is suspended vertically above the flame, and is connected with the copper body of the chamber by an arm; the heat of the flame is conducted to the chamber which is surrounded inside the wooden jacket by non-conducting material, and so changes of temperature inside are avoided. A screw allows the disc to be raised or lowered, thus producing more or less heat according to the temperature found necessary. It is found that this arrangement entirely removes any irregularity which might arise in the height of the flame due to the variation in temperature of the surrounding air.

An observer, therefore, working with the lamp merely requires to pour in some pentane into the small bulb leading to the mixing chamber, open the tap of the reservoir, and light the lamp. As soon as a steady temperature has been communicated to the chamber, which requires about 15 minutes, the height of the flame can be at once regulated by the screw of the box, and the flame will remain constant for a long time.

The height of the flame is determined by its just touching a platinum wire extended horizontally over it.

The wire is attached to a scale, engraved in millimetres, and capable of being raised or lowered by a rack and pinion movement. A pointer attached to the top of the burner, and level with it, marks the position on the scale, and so the wire can be immediately fixed at any height above the top of the burner.

The metal cylinder below the flame is of considerable value in steadying the flame by surrounding it with a cylinder of air, set in motion by the heat of the flame.

In a room, fairly free from draughts, this is amply sufficient to keep the flame quite steady, but as it is sometimes necessary to use the lamp in exposed positions, such as for instance, the gallery built for the lighthouse experiments at the South Foreland, where the lamp was used as the standard of light; a chimney can be used surrounding the flame and thus rendering it independent of draughts.

This addition has necessitated a number of careful experiments upon the absorption of chimneys, and it has been found that with glass of a constant quality and of a definite size there is a remarkably small difference in the absorption even if the thickness of the glass is slightly variable.

The reflection of the glass at the back appears to compensate in a remarkable degree for the absorption in front, and the total absorption of a good chimney does not exceed 3 to 4 per cent. Mr. Harcourt has made use of an ingenious device of a perforated plate on the top of the chimney, thereby slightly damping the flame and necessitating a small increase in the density of the mixture required to produce a flame of normal height. In this way the absorption can be almost completely compensated, and the size of the perforations has been determined so that the flame has only to be raised 0·3 mm. when the chimney is used, the difference only amounting to 1 per cent. in the value of the light. The plate has also the advantage of producing a remarkably steady flame, quite free from the fluctuations ordinarily seen in a flame surrounded by a chimney.

For the convenience of observers wishing to verify the height of the flame without interfering with the delicacy of vision necessary for photometrical work, an arrangement has been added by which a movable screen is placed in front of the flame, whereby the extreme point only is seen over the top, while another screen, covered with black velvet, is put behind the flame, so that the exact position of the flame can be verified at any moment.

An adjustable arrangement of plumb line and bob attached to the lamp, enables the lamp to be at once placed so that the flame is vertically above any required point on a table or photometer bar.

To further increase the accuracy of the lamp, Mr. Harcourt has established a law of correction of barometrical pressure, and the accuracy of this has been verified at the makers' factory during the periods of abnormal variations of atmospheric pressure.

In addition, the value of the light emitted by the flame at varying heights, from 40 mm. to 70 mm., has been accurately determined.

By means of this table it is very easy to make photometrical measurements by varying the height of the flame till equality of illumination is produced, and then lowering the wire till it touches the top of the flame, and reading the height by means of the engraved scale.

In some cases this method is preferable to any of the other well known plans.

The lamp is made by the Woodhouse and Rawson Electric Manufacturing Company, Limited, who are the sole makers, and in whose factory many of the details of the lamp have been designed and practically tested for many months of daily work with the lamp.

The lamps are tested by comparison with one of two verified standards in the possession of the makers, and also with that in daily use in the Gas Referee's Office in London, but it is found that the light is identical in all lamps the dimensions of which have been accurately gauged.

The experiments have been carried on under the supervision of Mr. Harcourt during the last fifteen months, and the reputation of the inventor as well as the practical experience and accurate workmanship of those entrusted with the work, ensure the perfection of the instruments produced.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

By A. RECKENZAUN.

(*Continued from page* 348.)

Analogy between Hydraulic and Electric Accumulators.—Some 40 years ago the first hydraulic crane was erected on a quay at Newcastle, and this crane had to work with a constant head of water 200 feet high in order to produce a pressure of about 90 lbs. per square inch upon the rams which moved the chains. To keep this pressure up, the water had to be pumped into a tank at the height indicated. It was some time after this, when Sir W. Armstrong discovered that if water be pumped into a pipe or cylinder fitted with a movable plunger, and if that plunger be loaded with weights, the enclosed water was in exactly the same mechanical condition as if it were in communication with a reservoir many feet above it. In either case the water is under pressure, whether that condition is caused by a load of metal or a load of water. The vessel which stored the water has been called an accumulator, because it actually accumulated the power of the steam engine, and it returned that power at a constant rate whenever requisite. The pumps worked by the steam engine supply the accumulator with water as fast, or nearly as fast, as the same is consumed by the hydraulic rams. So long as there is any water at all within such a cylinder containing a weighted plunger, there will be a constant pressure maintained. The stroke of the plunger, or the diameter of the cylinder, or, more correctly, the *capacity* of this hydraulic accumulator, had to be arranged in accordance with the supply and demand of water under pressure. If the demand is regular and the supply somewhat irregular, then this capacity must be large in proportion.

In the case of electric accumulators we have also to proportion the *capacity* according to the irregularity of the dynamo, or electric "pump," but that irregularity must be kept within very narrow limits; whereas the number of strokes of the water pump may for a few moments be reduced to an exceedingly low number; so long as the smallest quantity of fluid remains in the accumulator there will be a constant pressure due to the weight, whilst in the case of the storage battery a comparatively small reduction of speed on the part of the charging apparatus will cause a discharge of electricity from the accumulator into the generator. It is this great sensitiveness of the dynamo which renders the secondary battery statically unlike the hydraulic accumulator. When the supply ceases, the pressure of the hydraulic accumulator is practically constant until the last drop of water is squeezed out; with the battery, on the other hand, the pressure decreases considerably before the cells are entirely discharged.

Constructive details.—The Faure Battery.—We come now to the most difficult, and at the same time, the most important part of our subject. The success or failure of a secondary battery depends upon minute and apparently unimportant details of construction. One could scarcely imagine a simpler apparatus than, for instance, an original "Faure" battery, which consisted of sheets of lead, the surfaces of which were covered with a thin paste of red lead and the whole rolled up with some cloth or felt to keep them apart. This thing worked admirably for a short time, and the invention was hailed with enthusiasm even by the highest scientific authorities when first introduced into this country. Hundreds of tons of this crude form of storage battery were manufactured when it was still in that immature, untried condition. Instead of commencing careful experiments and gradually developing the invention of M. Faure, people at once began to manufacture these cells wholesale, and it was only after thousands of pounds were spent, and after many months' fruitless endeavours, that the great defects in this form of storage battery were discovered. Its utility was found to be great, but it was far from perfect. We agreed with Dr. Lodge when he wrote a few years ago that some day it may perhaps be recognised, that because it can be shown that a thing will be extremely useful when perfect, it does not follow that it has already attained that perfection, that, indeed, probabilities based on historical developments are enormously against such abnormal and instantaneous maturity, and that the careful nursing and rearing necessary to healthy maturity are better given in the seclusion of laboratory and study than in the excited and heated atmosphere of the Stock Exchange.

It is doubtless recognised already that all preliminary operations are better conducted on a scale smaller than the wholesale manufacturing one. In developing a new industry there are scientific difficulties to overcome, and there are manufacturing difficulties. By scientific difficulties, we mean such as the determination of weak points, the best way of strengthening them, and generally the discovery of theoretically the best modes of effecting the object in view; the manufacturing difficulties begin with questions of expediency and economy—how most cheaply and satisfactorily to carry out the indications of theory, to obtain this or that material—and includes the organisation of a system of manufacture, of division of labour, of machine tools, which shall enable the work to be done with economy, security and dispatch. Over-haste in the preliminary stages caused both these sets of difficulties to be tackled together, and thereby threw a grievous burden on all concerned. All these untoward conditions have storage batteries experienced; and to say that they have not fulfilled the hopes of their early promoters, is no more than to say that those hopes were untimely and unreasonable.

The main difficulties which were found with the Faure battery were firstly, that the red lead paste would not adhere to the smooth sheet lead; it became detached in flakes; secondly, the wrappings of cloth or felt became corroded with the acid; and thirdly, the separating material, being comparatively dense, prevented the circulation of the electrolyte; the acid was in consequence exhausted in some parts and concentrated in others, altogether there was too little of it in the immediate vicinity of the plates. There was greater activity consequently in some parts of a plate than in others.

The detachment of the oxide coating was not entirely due to a want of cohesion between it and the smooth lead plate. Sheets with roughened surfaces were tried with no better results. The peeling off is partly due to the fact that the acid penetrates through the pores of the coating and creeps up between it and the sheet lead when sulphate is produced, and patches of the substance are by this means rendered inactive owing to the insulating properties of lead sulphate. The main evil, however, lies in a different direction, and this has probably never been explained; it is this, the paste expands during oxidation and also when sulphating; the minute particles must then travel along upon the surface of the metallic support, which does not expand, and thereby diminish the adhesion of the paste which was originally smeared upon the lead plate and dried before placing it into the box with acid.

(*To be continued.*)

ELECTRIC LIGHTING AT THE ROYAL AQUARIUM.

THERE has recently been an extension of electric lighting at this popular place of amusement. The installation now consists of a 30 H.P. (nominal) Robey compound fixed engine, thirty arc lamps of 2,000 C.P. each, taking 8 ampères and 45 volts, ten arc lamps of 3,000 candle-power each, taking 16 ampères and 45 volts, and about 200 incandescent lights of 16 candle-power and forty of 10 C.P., and two No. 4 Gülcher low-tension dynamos, each capable of generating about 20,000 watts. The engine is furnished with two flywheels 7 feet in diameter, which run at 118 revolutions per minute; the boiler pressure being 120 lbs. to the square inch. To the engine is attached a Richardson's patent governor, which does its work well. The dynamos, which at 65 volts each, give 320 ampères and 425 ampères respectively, are run at 490 and 570 revolutions per minute. Each is driven from a flywheel of the engine by an 8-inch Gandy belt, travelling at 2,560 feet per minute. On the switch-board there is a large exchange switch, by which one dynamo can be switched on to the most important circuits should the other break down; there are two main switches carrying 200 ampères, and four 80 ampère switches, so that there are six circuits in all leaving the dynamo room.

Two main cables, which run the whole length on opposite sides of the building, one of 19 strands of No. 10 B.W.G., which tapers to $\frac{1}{15}$th and another of 37/15, are carried up in the roof on specially made insulators. From the 19/10 cable on the stage side of the building there are taken circuits to eight arc lamps of 3,000 C.P., seven of which are placed in a straight line down the centre of the building and one on the stage, about sixty incandescents, forty of which are used for stage effects, together with a 500 C.P. hand arc lamp, a device of Mr. Mountain's, which takes the form of a pair of sugar tongs, and for the short time it is required does its duty remarkably well. The other incandescents light some working models, &c.

The 37/15 cable on the opposite side supplies current to nine 2,000 C.P. arcs, six of which are under the galleries, and 160 incandescents. An installation in the Imperial Theatre, taken off at the extreme end of this cable, consists of fifty-one incandescents and three arcs of 2,000 candle-power. Forty incandescents light the fish tanks and 45 the dining rooms and refreshment bars of Messrs. Bertram and Roberts, the rest being used for the lighting of stalls under the galleries, billiard rooms, &c.

In the Imperial Theatre all the switches are placed behind the scenes, so that the stage manager has control of the lights during the performance.

The rest of the circuits supply seven arcs of 2,000 C.P. outside the Aquarium, six in the upper galleries and roof, and six in St. Stephen's Hall. The time of lighting is from half an hour before sunset till 11.30. The whole is under the charge of Mr. A. J. Baron, of the Gülcher Electric Light Company.

THE ROYAL JUBILEE EXHIBITION, MANCHESTER.

The Royal Jubilee Exhibition at Manchester was declared open on Tuesday last, May 3rd, by H.R.H. the Prince of Wales, who was accompanied by the Princess of Wales, with the usual amount of ceremony attached to such occasions. It is satisfactory to note that all passed off most successfully, and the attendance was probably never surpassed at any ceremony of a similar character. The building itself and all the exhibits were in such a complete state for an opening day as probably has never been seen before, for the chaotic condition of exhibitions on "opening day" has become proverbial. The General Manager, Mr. S. Lee Bapty, has weathered the numerous shoals and difficulties which have met him in his course, and he is to be sincerely congratulated on the success of his labour in navigating the undertaking into the certain tide of success.

The electric lighting arrangements have been already described, and it is only necessary to add that, so far as the incandescent lighting was concerned, everything passed off as well as could be wished, giving the utmost satisfaction to everybody. The sections known as the dining-rooms, and Old Manchester and Salford, were thoroughly lighted, and the quaint streets of the latter were thronged with visitors all the evening.

The Fine Art Galleries closing at seven o'clock, the 1,620 incandescent lights were not required, but as we saw them in full brilliancy for some hours the previous evening, there is no doubt about them. The arc lighting, however, was not in its complete state, and much appears to have been left undone, for not one half of the total number of lamps were burning, and much disappointment was felt, as in some of the sections—the Irish especially—the exhibits could not be seen after dark. It is much to be regretted that a commencement was not made earlier in wiring this system.

With regard to the electrical and telegraphic exhibits in the building generally and in the machinery annexe in particular, we may state that there are many of an interesting character which will merit description on another occasion, but some mention is necessary to be made of the very large amount of motive power required for the electrical and mechanical objects of the exhibition.

Close alongside the dynamo room is the boiler house, containing ten of Galloway's largest boilers, which supply the motive power for the four driving engines in the machinery annexe, and also for the numerous engines which drive the various dynamos required for the two systems of arc and incandescent lighting. Each of these boilers is of 400 indicated horse-power, is 30 feet long by 8 feet in diameter, and contains two furnaces and a Galloway back flue, with 38 Galloway cone tubes and water pockets. These boilers are entirely constructed of the best selected steel plates, and are made suitable for an ordinary working pressure of 100 lbs. to the square inch. They are furnished with a complete set of mountings of the usual type. They will evaporate 80,000 lbs. of water per hour, and it will thus be seen that with ordinary condensing engines they are capable of providing sufficient steam for upwards of 4,000 indicated horse-power. It may be mentioned that Messrs. Galloway have fitted up the whole of the steam and exhaust piping throughout the exhibition.

The dynamo room is placed at the extreme end of the buildings south of Talbot Road; it measures 140 feet by 100 feet, and contains the complete electric lighting plant for the whole exhibition. In addition to the various dynamos mentioned in our last issue, there has been fixed a "Manchester" dynamo driven by a Mather and Platt diagonal pair of engines. This dynamo acts as a "generator" for a "Manchester" motor (transmitting about 20 horse-power), which drives a massive cotton printing press, exhibited by Messrs. Mather and Platt, and which will be described amongst the exhibits.

The four dynamos (lent by Messrs. Mather and Platt) for lighting the Fine Art Galleries consist of two Edison-Hopkinson dynamos, each of 500 lamp-power, used during last year's exhibition at South Kensington, and two new compound-wound dynamos of the "Manchester" type, of a capacity of 700 lamps. These dynamos are driven by link belting, with jockey pulleys for tightening them, from a pair of very large and unusually massive high-pressure vertical engines, built by Messrs. Mather and Platt for use ultimately at their own works. The two engines work disconnected, and are mounted together. Each engine is capable of indicating up to 150 horse-power, and is provided with patent automatic cut-off, and has the cylinder steam-jacketted.

The special feature with regard to these engines of Messrs. Mather & Platt is in the fact that they were designed for mills or factories, where the floor space at command is limited. In this they have thoroughly succeeded.

Next to these engines is a "Robey & Co." compound engine, working up to 100 indicated horse-power, driving two Edison 250-light dynamos, and two 250-light Edison-Hopkinson dynamos. A Ruston-Proctor and Co.'s compound engine (100 H.P. indicated) drives two 250-light Edison dynamos, and one 500-light Elwell-Parker new type dynamo. These dynamos* are used for the incandescent lighting of the dining-rooms and Old Manchester and Salford, which is arranged in three circuits.

The remainder of the engines are employed in dividing the various "Brush" dynamos, all of which are in position. These are a compound engine of 40 H.P. by Ruston, Proctor & Co. (100 indicated); a Robey and Co. twin high pressure of 120 H.P. indicated; a Hornsby & Co. twin high pressure 190 H.P. indicated; a Robey & Co. single high pressure 90 H.P. indicated; a Messrs. Yeats (Blackburn) twin high pressure 150 H.P. indicated; and a 25 H.P. nominal Davey-Paxman & Co.'s vertical engine.

The remainder of the engines, with the exception of a small vertical high-pressure Davey-Paxman engine, which drives direct two Brush dynamos, drive the various dynamos by means of counter-shafting (4½ inches) and wrought iron pulleys varying from 7 feet to 2 feet in diameter, made by Perkins, Son and Barrett, of Bradford, Yorkshire.

The fairy fountain is worked from an ornamental tower, placed in the shrubbery near the lake in the gardens. The fountain is 120 feet in diameter, and is the largest yet constructed, the electric light and water power being three times greater than that at the Indian and Colonial Exhibition. The manipulating tower, erected in the form of a "pagoda," contains two storeys, the first of which is reserved for visitors, whilst the upper floor is appropriated to the operator, who will work the fountain with an elaborate arrangement of slides, directing the light on the water and steam used in obtaining the effects. Beneath the fountain is a large room, connected with the manipulating tower by a subway, for the convenience of the operator and his assistants. Messrs. W. & J. Galloway & Sons, of Manchester, have carried out the contract in connection with the fountain, including the supply of engines, pumps, electric lights, &c. The fountain power room is placed at the extreme end of the machinery annexe, farthest from the boiler house, and contains a compound horizontal engine of 200 indicated horse-power on their well-known twin system, which has cylinders 15 inches and 20 inches diameter respectively, with a stroke of 30 inches, and drives two dynamos for illuminating the fountains. These dynamos are of Messrs. Siemens's make, B 13 size, each being equal to a current of 450 ampères, with an E.M.F. of 250 volts when running at 300 revs. per minute. In the same house is also fixed a superposed horizontal compound engine of 185 indicated horse-power for working the six ram pumps which furnish water, at sufficient pressure to throw the fountain jets the necessary height to make an effective display. These pumps are capable of delivering a volume of water up to 200,000 gallons per hour under pressure varying from 10 to 100 lbs. per square inch, and are well adapted for fire or similar purposes.

The fountains, it may be stated, consist of a modification and improvement of those exhibited in London, upon which the late Sir Francis Bolton worked so assiduously, but the number and power of the jets and electric lights are considerably increased, the former being divided into ten different systems, each of which may be brought into operation and adjusted with regard to height as may be required, thus giving an infinite variety of combinations. Eighteen powerful electric arc lights of 60 ampères each are placed under the fountains, giving the brilliant illuminating power necessary for throwing from time to time upon the water jets, the ever-varying colours which form such an attractive feature in these fountain arrangements. The total illuminating power of these arc lamps is given as being equal to quarter of a million candles. The method of working the coloured slides has undergone considerable improvement, by which a vast amount of labour has been saved, and greater facility of operation and efficiency obtained.

The approbation and expressions of delight at the beautiful changes in the "fairy" fountain were universal, and it goes without saying that this will be one of the most attractive features of the whole exhibition.

NOTES.

Electric Lighting in St. Petersburgh. — A correspondent has sent us the following translation from a Continental paper:—"The Imperial Winter Palace in St. Petersburgh has one of the finest and largest electric light installations in the world, which receives its power from a central station. Formerly the palace was lighted by means of gas, candles, and oil. In 1885 trials were made with the installation of electric light. These experiments were so successful, that it was agreed to extend it, and now there are in the palace alone upwards of 20,000 incandescent lamps varying from 5 to 50 C.P., while in the various courts surrounding the palace 85 arc lights varying from 200 to 2,000 C.P. convert night into day. It is interesting to know that the annual cost is less now than with the old system of lighting. The whole of the installation has been carried out according to the plans of M. Paschkof. Boilers, engines, cables, and other apparatus have all been constructed in Russia by Messrs. Siemens and Halske, San Galli, Leschner, Chopin and others. There are six boilers, four engines, each of 300 H.P., a semi-fixed engine of 125 H.P. and two portable engines of 100 H.P., making a total of more than 1,500 H.P. The exhaust steam from the cylinders is used in the winter to melt the snow on the roofs of the palace."

Electric Lighting of an Underground Railway.—The subway from the Monument to Kennington and Stockwell, the Bill for which was last week passed by a select committee of the House of Lords, is to be lighted by electricity. The carriages which will convey the traffic through this subway will be worked by means of endless ropes.

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* The four 250-light Edison dynamos are the original 3 pair field magnet dynamos manufactured by Mr. Edison in New York about six years ago. These dynamos have been running the incandescent lighting at the Theatre Royal, Manchester, for the past four years—since December, 1882.

The Proposed Electric Lighting of Winchester.—Public opinion at Winchester is strongly in favour of the adoption of electricity for the purpose of illuminating the principal thoroughfares of the city, at present so inefficiently lighted by means of oil lamps. The offer which has been made by Messrs. Laing, Wharton and Down will be fully considered at the next meeting of the Corporation, and the vexed question of lighting at length settled "for better or for worse." In consideration of the Town Council entering into a five year's contract, the firm mentioned is willing to put down the necessary generating plant at a central station, to supply all the necessary circuits, lamps, pole irons, and heads complete, and to provide for lighting purposes, from dusk to daylight, any number of arc lamps exceeding 20, each of 1,200 C.P., for the sum of £22 per annum per lamp, the system used being, of course, the Thomson-Houston, which has proved such a great success at Taunton. The conditions are, among others, that power shall be given the contractors at any time to sell the central station as a going concern to responsible parties—the Corporation being afforded the first opportunity of purchase. Two schemes are submitted by the Lighting Committee. One provides for the partial electric lighting of five of the principal streets with 25 arc lamps at a cost of £550, the oil lamps remaining costing £749 5s. 0d.; the other to extend the number of thoroughfares and make use of 60 arc lamps costing £1,320, making the total annual outlay for lighting £1,900, as against the present cost of £884 5s. 0d. It is considered probable that the first scheme will be agreed to.

Electric Lighting of Docks.—A portion of Grimsby Docks is to be lit with the electric light. The work has been entrusted to Messrs. Drake and Gorham.

Folkestone and the Electric Light.—A proposal was raised in the Town Council of Folkestone last week that a portion of the town should be lighted by the electric light. The Mayor protested that, judging by what he had seen at Hastings, gas lighting was preferable on every ground to electric lighting; it looked better and was cheaper. So the proposal was dropped.

Electric Lighting at the Indian and Colonial Exhibition.—From the detailed accounts of the Indian and Colonial Exhibition, which have just been published, we gather that the expenditure upon and necessitated by the electric lighting of the exhibition buildings and grounds amounted to nearly £33,000. The general lighting of the exhibition, exclusive of the gardens, cost £19,335 11s. 4d. Included in this and under the heading of "plant purchased," the figures £4,533 17s. are given, representing wire, lamps, insulators, holders, ironmongery, &c., including plant, &c., taken over from the International Inventions Exhibition, of 1885. Upon contracts for lighting and for the hiring of steam power, dynamos, belting, pulleys, &c., the sum of £10,830 13s. 8d. was paid; oil, waste, and stores absorbed £211 13s. 8d.; for wages, the payments amounted to £2,098 8s. 8d., whilst an additional £1,660 18s. was paid in salaries to the engineer and staff, and as honoraria to the committee of experts. The contractors for illuminating the gardens received £10,096 17s. 6d., and £2,779 6s. 1d. was expended upon the illuminated fountain. The contract for running the plant for the fountain and the hire of the plant made away with £2,123 11s. 4d.; plant and fittings purchased costing £465; wages in this department amounted to £190 14s. 9d., and structural alterations for the purposes of the garden illuminations, cost £576 2s. 9d. The totals under the three headings are, therefore:—Exhibition, £19,335; gardens, £10,673; fountain, £2,779, or a grand total of £32,787.

Too Troublesome.—The grand electric lighting of the Grand Hotel in Brussels, as the *Gas World* puts it, has died through too continuously needing repairs and rectifications, and thus keeping both the hotel people and the electricians in a constant turmoil.

Electric Lighting in Spain.—A proposal has been made to instal the electric light at Guadalajara, using as the motive power a turbine of about 40 H.P., which is already erected about two miles distant, and employing Zipernowski transformers. The promoters, *Industries* states, are ready to carry out the scheme if they can obtain subscribers for 200 lights of 12 C.P. As the place has 8,000 inhabitants, and as there are no gasworks, there should be no difficulty in obtaining customers for 1,000 lights.

Electric Lighting in Milan.—The Milan Electric Lighting Company (Edison) has declared a dividend of 2·8 per cent. on its capital of £120,000, and carried forward £212 5s. 4d.

Electric Lighting of Travelling Shows.—Many of the travelling theatres, circuses, and similar entertainments, which are a conspicuous feature at the various fairs held in Paris, and which are sometimes of considerable dimensions, are adopting the electric light, using both arc and glow lamps.

Telephoning between Paris and Brussels.—It is stated that the telephone service between Paris and Brussels is proving insufficient for the demand. The French and Belgian authorities are therefore contemplating the construction of a second line *viâ* Quiévrain.

Government and the Telephonic Systems.—The Convention of Royal Burghs at its recent annual meeting resolved to memorialise Government suggesting the acquirement of the existing telephonic systems and working them as a branch of the Postal Service. The Postmaster-General replied that the memorial should receive careful consideration.

The Telephone in Cumberland.—The Cockermouth Exchange of the National Telephone Company was opened on Wednesday last week, and verbal communication can now be held between Cockermouth and Maryport, Workington, Whitehaven, Parton, Cleator Moor and Frizington. There are as yet only four firms at Cockermouth who have availed themselves of the facilities offered by this means of communication, but doubtless when the advantages become better known there will be an accession to the list.

Royal Institution of Great Britain.—The lectures on electricity which were to have been delivered at this Institution by Dr. John Hopkinson, F.R.S., are now, in consequence of that gentleman's illness, being given by Professor Ayrton, F.R.S. The first lecture, which dealt with the cost of electricity, was delivered on April 26th; and the second, on "Apparent Momentum of Electricity produced by Magnetic Inertia," on Tuesday last. A third lecture, on "Self and Mutual Induction," will be given on Tuesday next.

The Colonial Delegates.—By invitation of the Postmaster-General, the delegates from the Colonies to the conference now sitting, proceeded to Woolwich, on Thursday, and there inspected the *Monarch* and other telegraph ships.

Personal.—Mr. William Nisbet, assistant telegraph superintendent at the General Post Office, Glasgow, has out of many applicants been appointed to the vacant postmastership of Inverness, which carries with it a salary of £450 a year. Mr. Nisbet was superintendent of the British and Irish Magnetic Telegraph Company in Glasgow prior to the transfer of the business of the old telegraph companies to the Post Office.

Miners' Electric Safety Lamps.—We learn that the Executive of the Newcastle Mining Exhibition has acceded to the requests of "A Coal Hewer" contained in the article which we published last week, and miners and all others who may feel sufficiently interested will be able to form their own opinions as to the value of electric safety lamps for mining purposes.

Electricity in Yorkshire Mills.—We referred last week to the lighting of Messrs. Campbell and Harrison's wool factory at Bowling. Messrs. Woodhouse and Rawson now inform us that in addition to the engines we mentioned as forming part of the installation there is a supplementary engine of 30 H.P., which alone is capable, upon an emergency, or during the stoppage of the main engine at meal times, of carrying the major part of the lamps. In addition to lighting the premises the dynamos furnish current for actuating a small electric motor used for working an electric tramway for conveying wool from one end of the premises to the other.

Obituary.—Mr. Charles Walker Morse, eldest son of Prof. Samuel F. B. Morse, died at Saybrook, Conn., of internal cancer, on April 16th. Mr. Morse shared the labours of his father in the early struggles of the electric telegraph, and also rendered experimental assistance to Colonel Colt, of revolver fame.

Copper Refining by Electrolysis.—Mr. Guy C. Fricker is writing a series of articles on the subject of "Copper Refining by Electrolysis" for *Industries*.

New Units.—Prof. Ayrton has been inventing lots of new units. But the question is whether the electrical world does not get weary of them? We recollect Sir W. Thomson's "*mho*" and Prof. Thompson's "*gauss*." They were not happy suggestions, and we fear those now proposed will only share the same fate.

Specifications Published.—No. 3,675, Improvements in transmitting motive power from electro or other motors and apparatus therefor, James Gibson, 16th March, 1886; No. 6,471, Improvements in electric telephony, James Grieve Lorrain, 13th May, 1886; No. 6,487, Improvements in simple and compound switches for electrical currents, Wilson Hartnell, 14th May, 1886; No. 6,508, Improvements in electric meters, Robert Percy Sellon, 14th May, 1886; No. 886, An electric heat-detecting alarm, John Adair, 20th January, 1887; No. 1,750, Improvements relating to the electro deposition of aluminium and to apparatus therefor, Henry Harris Lake, 3rd February, 1887; No. 2,079, Improvements in means or apparatus for controlling telephonic communications, John Gill, 10th February, 1887; No. 2,377, Improvements in electro-magnetic brake systems, George Francis Card, 15th February, 1887; No. 5,078, Improvements in electric lighting apparatus for use in wheeled vehicles, Richard Weber, 12th April, 1886; No. 5,089, Improvements in electric arc lamps, François Fesquet, Stanislas Julien, Count Ostrovog, 12th April, 1886; No. 6,422, Improvements in armatures for magnets or dynamo-electric generators or motor, J. G. Statter and S. L. Brunton, 12th May, 1886; No. 6,507, Improvements in appliances for use in electric lighting, R. P. Sellon, 14th May, 1886; No. 6,869, Improvements in the transformation of heat into electricity and in apparatus for that purpose, Charles Clamond, 21st May, 1886; No. 7,463, A new or improved electro-chemical etching process, H. E. P. Dorn, 3rd June, 1886; No. 8,040, Improvements in regulating alternating electric currents, C. Zipernowski, Max Déri, and O. T. Blathy, 16th June, 1886; No. 10,186, Improvements in electric generators and motors, C. W. Hill, 10th August, 1886; No. 1,400, Improvements in automatic apparatus for subjecting the person to the action of electric currents, A. Loiseau and O. Pierrard, 28th January, 1887; No. 2,835, Improvements relating to electric batteries and to means for putting the same into and out of circuit, G. V. Lagarde, 23rd February, 1887.

The Society of Telegraph-Engineers and Electricians.—The next meeting will be held on Thursday, May 12th, at 8 p.m., when the adjourned discussion on "Measuring the Co-efficients of Self and Mutual Induction" will be resumed, and a paper on "Driving a Dynamo with a very Short Belt," by Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., will be read.

Volk's Electric Railway.—The threatened suppression of this railway still continues to agitate public opinion at Brighton, and a strong feeling undoubtedly exists that the corporation will perpetrate a high-handed act of tyranny if it calls upon Mr. Volk to remove his rails from the sea front. By many it is considered that the alleged dangers arising from the railway are almost purely imaginary, and are devised by those who, for selfish reasons, perhaps, desire to put an end to the cheap and rapid mode of conveyance provided by the electric railway. A suggestion has been made that Mr. Volk should place a wooden horse's head at the front of his car, so as to obviate the likelihood of animals being frightened by the appearance of a car gliding smoothly along without any visible means of motion.

Varnishing Incandescent Lamps.—Mr. Arthur Shippey writes to say that he is much against the system adopted of varnishing incandescent lamps, on the score of economy, seeing that lamps of any desired tint and colour can be obtained, made of real-coloured glass, at about 3s. per dozen extra. Any chemical or varnishing process, however good it may be, he says, is bad for this purpose, and detrimental to the life of the lamp, as varnish absorbs and retains moisture, and does not allow for proper expansion of the bulb when heated by an excessive flow of current. At its best, the varnishing process can only produce a dirty and unsightly lamp, which greatly obscures the light. Referring to the varnished lamps used at the South Kensington Exhibitions, he says it would be interesting to know how many times the lamps used at the exhibitions were re-dipped and how many bulbs were broken; also how many men were kept continually employed to carry out this process. Mr. Shippey adds that his firm controls the patents for coloured and fancy glass for the bulbs of incandescent lamps, but licenses, providing for the payment of a small royalty, are extended to other firms.

Electricity in the Royal Navy.—During their recent visit to Portsmouth, the members of the National Union of Elementary Teachers were accorded a capital opportunity of inspecting the elaborate electrical and torpedo apparatus on board the torpedo school ship *Vernon*, lying in the harbour. The application of electricity to the varied requirements of the Navy was fully explained, and some miniature mines were exploded by means of electricity to illustrate how extensive operations of that kind are carried out. An electric light of 25,000 C.P. was also shown.

Transformers.—Mr. J. E. Talbot, in the New York *Electrical Review*, writing of the above, says, "The most rational and scientific worker on the subject, so far, at least, as appears from any published utterances on the matter, was Rankin Kennedy, a Scotch professor, and the inventor of an alternating current dynamo which bears his name." Mr. Talbot evidently confuses the late William John Macquorn Rankine with Rankin Kennedy; both have done good work, but the former never designed a transformer, and the latter never sat in the professorial chair.

Electric Locomotion in America.—Electric railways are now running, or building, or under contract in New York City, Philadelphia, Baltimore, Boston, San Francisco, Detroit, Ansonia, Conn.; Montgomery, Ala.; Pittsburgh, Los Angeles, Cal.; Denver, Col.; Windsor, Can.; Scranton, Pa.; Carbondale, Pa.; Ithaca, N.Y.; Binghamton, N.Y.; Lima, O.; Appleton, Wis.; Orange, N.J.; Kansas City, St. Louis, Chicago, and Cincinnati. Some of these places will soon have two or three roads running. There are also scores of places, says the *Electrical World*, where roads are seriously proposed, like Newton, Mass.; Bangor, Me.; Selma, Ala.; Birmingham, Ala.; San Diego, Cal.; Atlanta, Ga.; Jacksonville, Fla.; Reading, Pa.; Brooklyn, N.Y.; and Jersey City; and a great many other places might be mentioned if the negotiations were ripe enough to admit of publicity.

Unit of Self-Induction.—For the commercial unit of self and mutual induction, Prof. Ayrton, at the Society of Telegraph Engineers last week, suggested the name "*secohm*" as being a convenient contraction for second-ohm. Prof. Ayrton thinks that, to put it the other way about, that is, ohmsec, the name would look too much like the cockney method of pronouncing *home-sick*.

Electrical Execution of Murderers.—At Harrisburg on April 6th, the Pennsylvania Legislature passed a Bill providing that punishment for murder in the first degree may be death by the use of electricity.

Miner's Safety Lamps.—The *English Mechanic* states that a clergyman in Yorkshire has obtained a patent for a "safety electric lamp for miners." The chief feature in the device is "the interposition of wire gauze between the carbon of an incandescent lamp and the exhausted envelope of glass in which the carbon is contained, so that in case of fracture of the glass the carbon is prevented from igniting any combustible mixture of gases or coal-dust surrounding it."

Gas Explosions.—Much excitement was caused in the Strand one afternoon last week by an explosion of gas. Some of the men of the Post Office Telegraph Department were engaged in mending the underground wires at one of the outlets near Villiers Street, and one of them struck a light in order to ignite a small spirit lamp. The immediate result was a loud explosion 25 or 30 yards away, and two large stones were blown into the air. Fortunately, no one was injured. It is thought that a quantity of gas must have entered the tube containing the wires owing to a leak from the gas pipes underneath, and that the gas exploded at the first point where it could get vent.

Early on Thursday morning last week the Farringdon Street Station of the Metropolitan Railway Company was the scene of a serious outbreak of fire, the result of an escape and slight explosion of gas. A considerable area of the flooring and joisting was ignited, but the damage was restricted to the refreshment rooms on the ground floor.

Electric Tramway near Munich.—M. S. Schuckert has recently constructed a small electric tramline between Schwabing, a suburb of Munich and the baths at Ungerer. The line is 750 metres long. One car capable of holding 40 passengers makes the journey in 2½ minutes. A portable steam engine at one end of the line actuates a Schuckert dynamo which gives a maximum current of 38 ampères with 220 volts when the car is running up the incline, and 22 ampères with 215 volts on the level. In the former case the engine gives off 14 H.P., and in the latter 7·5 H.P. The rails are used as conductors. No. 11 of the *Centralblatt für Electrotechnik* gives an illustration of the car, but there is nothing novel in its arrangements. The motor is placed underneath the car and the power is transmitted to the axles by means of a broad strap.

Double Pole Cut-out.—We have before us a simple and efficient form of fusible double pole cut-out which has been invented and brought out by Mr. Rashleigh Phipps, who by-the-bye, in consequence of the great increase in his business, has been obliged to remove to his present more spacious premises at Nos. 185 and 187, Gray's Inn Road. The break, unlike many of the cheap articles so commonly sold, is of such a length as to entirely prevent the possibility of continuous "arcing." The bases and covers are made entirely in slate, marble, or other uninflammable materials, and the two fuses are entirely separated by a spacing piece on the cover. These cut-outs are such as cannot fail to satisfy the insurance authorities; and they are manufactured in all sizes to suit wood casing.

Magneto Electric Bells and Signals.—We are informed that within the next few days the prospectus will be issued of a company intending to work the Abdank-Deprez patents for magneto-electric bells, the probable formation of which was alluded to in our "Notes" columns on the 11th February last. Electric bells, telephone calls, and electric signals have hitherto depended largely for their action on voltaic batteries, and these are not only sometimes difficult to maintain in working order, but are always costly and incurring expenditure for replenishment. Frequent failures result from the uncertain action of batteries, and to avoid such troubles electricians have endeavoured to avail themselves of the well-known principles of magnetism, and magnetic appliances have been used for telegraphic and telephonic purposes, but their complicated and cumbersome character have mostly excluded them from general use, although some years ago a number of public buildings and hotels were fitted with the system of magnetic bells devised by the late Sir Charles Wheatstone. From causes, however, which may or may not affect this latest development of the magnetic system of bells, Wheatstone's apparatus could not be called an unqualified success and we have yet to learn from experience whether the Abdank-Deprez instruments will fare much better than their predecessors, although we are bound to confess that their success or failure will depend mainly upon the technical staff of the company. The Deprez-Abdank magneto-electric apparatus consists of two small magnets, between the poles of which a coil of insulated copper wire is suspended on a stiff and lively blade spring. When this coil is made to vibrate by a slight pull with the hand or finger, a current is instantly induced The apparatus is in reality an improvement on that described and illustrated in the REVIEW for August 18th, 1883. Excepting for telephone call-bells, these small transmitters and bells are not generally required for long distances, the great demand being for bells and indicators in public buildings, houses, offices, hotels, clubs, factories, &c. When large sounding gongs are required, the apparatus is simply increased in size, and an apparatus of this kind has been in operation for many months on a Continental railway, signalling over a distance of 600 miles. We have on several occasions inspected the apparatus manufactured under the Abdank-Deprez patents, and we have not the slightest doubt that if the projected company is well-managed it will command a more than usually successful career, for there is apparently no limit to the uses to which these simple and inexpensive instruments can be put. In our next issue we shall try to find space for a more lengthy and an illustrated description of the system, and in the meantime we may mention that a very complete installation, arranged to demonstrate the applicability of the apparatus to a variety of purposes, may be seen at the office of Mr. L. Saunders, 2, Austin Friars, E.C.

The Swansea-Mumbles Line.—We shall be glad if any of our correspondents can give us further particulars respecting the working of this railway, which was mentioned in the course of discussion on Mr. Reckenzaun's recent paper. We have already pointed out that the lessees of the line have expressed their willingness to adopt electrical traction if it is shown to their satisfaction that it can compete with the steam locomotives now in operation. We shall be glad to learn that some steps have been taken to investigate this very important matter.

Small Dynamos.—The description of the eight-light dynamo designed by Mr. Hopkins will doubtless interest a large number of electrical students, many of whom will assuredly strive to construct a similar machine for their own uses. Mr. Hopkins frequently writes on scientific topics in the *Scientific American*, and his descriptions and illustrations of physical apparatus and experiments are models of what such things should be.

The Electro-Harmonic Society.—The second smoking concert of this society took place on Friday evening last with an augmented and more representative attendance of members and their friends. Mr. W. H. Preece occupied the chair, and there were present no less than 13 members of the committee. The vocal element was of a very high order of excellence, Mr. Robert Hilton (bass) and Mr. Arthur Thompson (tenor) meeting with a very gratifying reception. The violoncello solos of Mr. W. C. Hann, a professional pupil of Signor Piatti, were charmingly performed, as were also the pianoforte selections of Mr. Alfred Izard who, in addition, accompanied throughout.

Electricity for Street Traffic.—The *Evening Standard*, remarking upon the advances of Science since the accession of her Majesty, calls attention to the remarkable exception to the general substitution of steam for horse-power to be witnessed in street traffic, and proceeds: "It would, indeed, rob town life of one of its most picturesque features if we improved the equine race off the streets of our cities. Yet such a thing is by no means impossible. Steam engines were objectionable in crowded thoroughfares owing chiefly to their noise; but electricity appears likely to be adopted where the steam locomotive was inadmissible. Certainly such a change will not be without its advantages in the case of towns. What we should lose in picturesqueness we should more than gain in cleanliness and a purer atmosphere."

NEW COMPANIES REGISTERED.

Electrified Rooms.—Capital: £25,000 in £1 shares. Objects: To carry on business as medical and general electricians, and to take over the business of existing company with same title. Signatories: A. W. White, Portsmouth, 300 shares; Lieut.-Col. J. W. Wallace, Southsea, 300 shares; D. C. Wordsworth, Southsea, 300 shares; J. R. Martyn, Portsmouth, 250 shares; Major F. B. Balkeley, Southsea, 300 shares; Major P. L. Gordan, Southsea, 350 shares; Arthur H. Byng, Southsea, 1,800 shares. Registered 2nd inst., without articles of association, by Messrs. Waterlow Brothers and Layton, Limited, Birchin Lane, E.C.

Kay Brothers, Limited.—Capital: £100,000 divided into 9,990 shares of £10 each, and 100 founders' shares of £1 each. Objects: To trade as chemists, druggists, and drysalters, and as manufacturers of and dealers in electrical, chemical, photographical, and scientific apparatus and materials. The signatories, who are all of Stockport, Cheshire, are as follows:—*Samuel Kay, 3,557 £10 shares and 10 founders' shares; *Thomas Kay, 3,558 £10 shares and 50 founders' shares; Mrs. S. Kay, T. P. Hardcastle, Mrs. T. P. Hardcastle, J. W. Leather, G. A. Down, one £10 share each. The first two signatories are appointed permanent directors, and will each receive £400 per annum salary. Registered 28th ult. by Mr. R. Jordan, of Chancery Lane. Registered office, St. Peter's Gate, Stockport, Cheshire.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Taunton Electric Lighting Company, Limited.—The statutory return of this company, made up to the 20th ult., was filed on the 27th ult. The nominal capital is £10,000 in £5 shares. 800 shares have been taken up, and upon 794 shares the full amount has been called, and £3 per share upon the remaining 15 shares. The calls paid amount to £3,718, and unpaid to £297. Registered office, 22 and 23, Fore Street, Taunton.

CITY NOTES, REPORTS, MEETINGS, &c.

Great Northern Telegraph Company of Copenhagen.

THE general meeting of this company was held at Copenhagen on April 23rd, when Mr. F. Zahle presided.

Mr. C. F. Tietgen, chairman of the company, in addressing the meeting with regard to the company's general business during the working year of 1886, said the state of the cables had been satisfactory during the year. Repairs had been speedily and effectually completed by the company's own two steamers, and the opportunity had on every occasion been seized at the same time to strengthen the cables in the most exposed places. Thanks to the company's general system of duplication, the traffic had at no time suffered any interruption or delay. The repairing steamer in the far East had, besides, undertaken cable repairing work for other parties, and earned a profit which had contributed to the reduction of the working expenses of the steamers to a maximum. The Russian Administration had further decided to adopt the system of the Wheatstone instruments at all international stations on the Wladiwostock line. The necessary instruments had been manufactured in the company's workshops at Copenhagen, and their installation had now been commenced with the assistance of the company's staff. In China the development of the Imperial Government land line system had progressed moderately. The construction of the line from Seoul, the capital of Corea, to Fusan, the landing point of the company's cable to Japan, was progressing, but it had not yet been completed. Several land lines in the Mantchuria, towards the Russian frontier, had been pushed on, and the line running along the Yangtse River had been extended beyond the town of Ichang. The traffic receipts, as had been foreseen at last year's meeting, had diminished, say for 1886 to the extent of about £27,000, as compared with those of 1885. This had in a great measure been owing to the tariff reductions established by the Berlin Conference, but the effects of the continued depression of trade had also made themselves felt. Since 1883, when this company duplicated the lines from Wladiwostock to Nagasaki and Shanghai, and when it was decided that the company's Shanghai-Hongkong line should be duplicated by the Eastern Extension Telegraph Company for their own account, there had been two telegraph stations situated close to each other belonging to and worked by this company and the Eastern Extension Company respectively, whilst as per previous agreement the revenues were equally divided. Such an organisation appeared more costly than strictly necessary, and it had therefore during the year been agreed to amalgamate the interests of the two companies in this respect also, so that in future a joint Hong Kong station will be managed by the Eastern Extension Company, where this company is represented by a Danish controller and three Danish operators, whereas the Shanghai station is managed by this company with an English controller and English operators representing the Eastern Extension Company. The object would now be jointly to defend the companies against the Chinese competition, which constituted violations of the Chinese concession, which he had referred to on a previous occasion, and to do this by making common application to the Chinese Government and the Chinese authorities, in order to maintain the legitimate rights of the companies in accordance with the concession granted in 1881. For this purpose the companies had applied to their respective Governments in Europe, who had assured them of the assistance of their Legations at Pekin. In referring to the balance sheet, the chairman said it was true that as against the falling off of traffic receipts, already referred to, there might to a certain extent be set off the increased receipts under the head of sundries and the reduced expenses, but it must be remembered that the former was of a perfectly sporadic nature—the company had been fortunate in acquiring these extra profits last year, but without any reasonable probability of their continuing—and the latter was more apparent than real, and mainly owing to readjustment of the Dollar Exchange formerly maintained by the company for book-keeping purposes, and as most of the expenses in the far East were paid in that coin the change had now become necessary. As it was, the directors proposed to the meeting to deal with the balance remaing after payment of all general and ordinary charges for interest and amortisation of debentures, and also of the usual 5 per cent. interim dividend during the past year as follows:—£37,500 to be divided amongst the shareholders as an extra dividend of 2½ per cent., making the dividend for the year, including the interims paid, 7½ per cent.; £2,777 15s. 7d. as endowment to the pension fund of the staff; £55,555 11s. 1d. to be added to the reserve fund; and £31,586 3s. 3d. to be carried forward to next year's account. The company had acquired new premises in London, which were both larger and more salubrious, for the office and station. The removal took place on March 22nd, and the address is now 3, St. Helen's Place, E.C. The chairman feelingly referred to the death of Mr. C. A. Broberg, one of the directors, which had occurred in the course of the year. He had been a director since the foundation of the company, and had always been hopeful of its success. The directors had invited Mr. A. Garde, formerly Governor of the Danish W. I. Islands, and who had acted as auditor for the shareholders, to join the board.

Without discussion, the propositions of the directors were unanimously adopted, the accounts were passed, and the usual discharge was given to the directors.

Colonel V. Hoskjær and A. Garde, Esq., were unanimously re-elected on the board.

Mr. A. Berner and Mr. S. Bille were likewise unanimously e-elected as shareholders' auditors.

The final dividend of 5s. per share for 1886 is now payable the company's bankers, Messrs. C. J. Hambro and Son, 70, Old Broad Street, London, E.C., against coupon No. 9.

West Coast of America Telegraph Company, Limited.

THE tenth ordinary general meeting of this company was held at Winchester House, Old Broad Street, on Tuesday, and was attended by three shareholders only besides the directors and the secretary. Mr. Alfred Marshall presided.

Mr. Fred. L. Robinson, the secretary, having read the notice convening the meeting, and the report, which appeared in the REVIEW last week, having been taken as read,

The Chairman said: You will notice that the chief feature of the report is that there has been a decrease in the working expenses of our steamer, and another feature of importance is that our gross earnings show a slight decrease from those of the previous year. The decrease in the expenditure is caused by the greater economy used by our captain and our servants out on the West Coast. The decrease in the earnings is attributable to the great depression in trade and to the loss in exchange which we have suffered. You are all acquainted with the fact that a long and disastrous war has been carried on during recent years, and although this is at an end, and although it has ended in the victory of Chili, the country with which we are chiefly concerned, it has still caused a great drain on the resources of the country, and naturally commerce has felt the result of it during the past years. At the same time the Chilian Government, in order to raise the funds necessary to continue the warfare, adopted the rather suicidal policy of issuing paper money. This has told on the exchange, and whereas in former years the dollar was worth 48 pence, it has gradually during the course of years dwindled down to about 22. I am happy to be able to mention that a reaction is taking place, notably since the month of October last, and that since then our earnings have correspondingly increased. If it had not been so we should probably not have felt in a position to pay the dividend which we distributed amongst the shareholders in June last. Not only has the exchange improved since October; there has been a marked revival in our traffic which we can only attribute to the gradual improvement of trade generally. We have also been aided by an otherwise very unfortunate circumstance. I refer to the cholera, which has been communicated from the Argentine provinces to Chili, and has necessitated the suspension of communication by steamer between Chili and Peru. This has thrown a great deal of traffic on to our lines, for letters even were not interchanged, and any communication that had to be made between Valparaiso and Lima had to be carried on by telegraph. This gave us a very large traffic in the first months of the year. The Minister of Finance in Chili has lately adopted measures which it is hoped, and very confidently hoped, will lead to the restoration of the currency within a measurable period of time. The measures consist in purchasing a certain amount of silver every month and in destroying a certain quantity of the paper money which has so much tended to depreciate the currency. We may by these measures hope gradually to reach again a rate of exchange which is somewhat equivalent to the value of silver, silver being the currency of the country. Before putting to you the adoption of the report, I would give you the welcome intelligence that during the first three months of this year our gross earnings have been £5,000 in excess of the earnings of the first three months of the year 1886, and if this satisfactory state of our traffic continues, we confidently hope not only to materially strengthen the position of this company by adding to the reserve fund, but also to distribute dividends at least as large as, if not larger than, any that have been distributed during any year that this company has been in existence. With these remarks I beg to propose the reception and adoption of the report and accounts.

Mr. T. Fielden Campbell seconded the resolution.

Mr. Martindale remarked that the auditor had taken exception to the investment of £10,000 of the reserve fund. He supposed there was some reason for that.

The Chairman said the remark which the auditor had placed at the end of the balance sheet was similar to the one he appended on a former occasion. The first investment of the reserve which they made was in the debentures of the company, and that investment had remained. Since the report was drawn up they had made an investment of the reserve in a more convertible security, but, of course, a security not bearing the same interest as that which they got from their own debentures. This security, in which they had invested £5,000, was the debenture stock of the Southern Mahratta Railway Company, which company was guaranteed by the Indian Government.

The adoption of the report was then agreed to.

The retiring directors, Mr. Campbell and Mr. Henry Roberts, were re-elected, and Mr. J. Weise, of Messrs. Turquand, Youngs and Co., was re-appointed auditor. A vote of thanks to the Chairman then terminated the proceedings.

The Railway and Electric Appliances Company, Limited.

COLONEL RAYNSFORD JACKSON presided over the fourth ordinary general meeting of this company, which was held at the offices, 27, Leadenhall Street. The following report was received and adopted:—The directors regret that although every effort has been made to minimise the expenditure and to secure business of a profitable character, the operations of the company have resulted in a further loss. The wagon cover fastener, the point rod compensator, and other appliances have been fairly productive, the prices obtained being on the whole satisfactory, but the aggregate of business done has been insufficient to cover all the fixed charges connected with the carrying on of the factory at Polmadie, Glasgow.

Where railway authorities have been induced to try the patents the articles supplied have, almost without exception, given thorough satisfaction, but owing to the continued depression in trade and the reluctance evinced by many railway companies to lay out money in improvements, the appliances referred to have not been adopted so widely as might have been reasonably expected from their undoubted utility; however, there are indications now that the marked success of these inventions will lead to their more general adoption, and as this should secure to the company a substantial revenue, the directors do not abandon the hope that ultimately the concern may be prosperous.

After much anxious consideration the directors have come to the conclusion that the sale or letting of the factory at Polmadie would contribute in no small measure to that desirable end, and either could be done without detriment to the company's business. If, therefore, the shareholders concur in this recommendation, steps will be at once taken to sell the factory, with the machinery and plant, or if that cannot be satisfactorily arranged, to let it on the best terms obtainable. The company would by this means derive material benefit, as not only would the permanent charges connected with the works cease, but in the former case the further capital thus made available would be of considerable use, whilst in the latter the rental should yield an appreciable gain to the company, as the feu is only £123 per annum.

If the above suggestion can be carried out, the operations of the company may be continued for another year with a confident expectation that, even if little or no business should be done, the loss would be comparatively trifling, whilst, if a moderate amount were secured in the particular inventions referred to, there would be a surplus at the end of the year, which might be enhanced by returns from other railway appliances recently placed in the hands of the company to work on royalty, and which have already been highly approved by experts.

If at the end of this year the business of the company should still be found to be unremunerative, or should the directors find before it expires that there is no prospect of success being attained, they will probably call the shareholders together, and ask them to sanction the dissolution of the company.

Notwithstanding that the actual business of the company has again been unprofitable the directors are of opinion that its general position has much improved, inasmuch as the share capital has been very largely reduced, and the effect of the adjustments made, or to be made, is practically to reduce the debit in the balance sheet for patents from £88,200 15s. 1d. to £37,250 15s. 1d., and to reduce the amount to the debit of profit and loss account from £31,981 11s. to £19,052 9s. 5d., after charging the loss during 1886: whilst there is an additional sum, £8,500, available for still further reducing the latter item, as shown by the extra number of shares which have been acquired on behalf of the company at a very small cost.

It should be explained that the purchase of the 8,500 shares ("D" account) was made, under legal advice, out of the sum standing to the credit of the directors in respect of their remuneration to the end of 1885, and that a further sum was appropriated from the same account to make all the said shares fully paid. The directors themselves were entitled to the full benefit of this transaction, but, it having been negotiated solely for the advantage of the company, they make no claim to the shares so acquired and paid up. Although the remuneration payable to the directors in terms of the articles of association has been debited to profit and loss account, the sum actually divided for last year was only £337 10s., and no portion of that accrued to date since September last has been drawn.

The retiring director, Lieut.-Colonel Elliot, was re-elected, as also was the auditor, Mr. James Worley, F.C.A.

The Brazilian Submarine Telegraph Co., Limited.

THE report of the directors for the half year ended 31st December, 1886, states that the revenue for this period amounted to £95,831 4s., and the working expenses to £12,935 17. 5d. After providing £11,555 for debenture interest and sinking fund, and £1,986 16s. for income-tax, there remains a balance of £69,353 10s. 7d.; to this is added £2,174 14s. 6d. brought forward from 30th June last, making a total of £71,528 5s. 1d. First and second interim dividends amounting to £39,000 have been paid, and £25,000 transferred to the reserve fund, leaving the sum of £7,528 5s. 1d. to be carried to the next account.

In accordance with the provisions for repayment of the first issue of debentures, dated 31st July, 1884, 371 bonds, representing £37,100, were drawn on the 26th April last, for payment at par on 31st July next.

The various sections of the company's line are in good working order.

Submarine Cables Trust.

THE report of the trustees states that the revenue for the financial year to April 15th, 1887, including the balance brought from the previous accounts, viz., £2,140 10s. 8d., amounted to £16,669 7s.

The trustees regret, that for the first time since the formation of the Trust, its revenue should have fallen short of the amount required to pay the half-yearly coupons in full. This is mainly owing to the Anglo-American Telegraph Company, in whose stock the Trust is so largely interested, having paid to its shareholders last year a dividend of only five shillings per cent.

It will be observed that, notwithstanding the diminished revenue of the Trust, the return to the certificate holders has been at the rate of 4½ per cent. for the past year.

A payment of £2 10s. was made on account of the coupon due on October 15th, and the balance of 10s. was paid on January 15th. Towards the coupon due on 15th inst. the trustees were only able to pay £1 10s., leaving a balance of £1 10s. to be paid as soon as sufficient funds are in hand for the purpose.

The expenses of the Trust amounted to £1,359 14s. 10d. and the payments on account of the coupons to £15,214 10s., together £16,574 4s. 10d., leaving a balance of £95 2s. 2d. to be carried forward. The securities held by the trustees remain unchanged.

Anglo-American Brush Electric Light Corporation, Limited.—It will be remembered that in view of an anticipated expansion of business the directors of this company, at the last meeting of the shareholders, obtained power to issue, as occasion might require, 10,000 additional shares, on which £3 per share was to be called up, the issue price to be not under par. The directors have now determined, we learn, to immediately issue 5,000 of these shares, and to offer them, in the first instance, to the existing shareholders, at par, in the proportion of one new share to each 10, or fraction of 10 shares registered in their names on April 27th, 1887.

Brazilian Submarine Telegraph Company, Limited.—The numbers are announced of 371 debentures which have been drawn for payment on July 31st next.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of April was 3,823, estimated to produce £2,900, against 3,964 messages, producing £3,349 in the corresponding month of last year. The receipts for the month of January, estimated at £3,200, realised £3,218.

The Eastern Extension, Australasian and China Telegraph Company, Limited. The receipts for April amounted to £35,955, against £34,292 for the corresponding period of 1886; increase, £1,663.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of April were £1,670, against £1,594 in the corresponding period of last year.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 29th were £3,275.

The Eastern Telegraph Company, Limited. The receipts for April amounted to £43,136, and to £47,611 for the corresponding period of 1886.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending April 29th amounted to £4,018.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending April 30th were £5,250.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this society was held on Thursday, April 28th, Sir CHARLES BRIGHT, President, in the chair. The usual general business having been concluded, a paper on "Modes of Measuring the Coefficients of Self and Mutual Induction," by Professors W. E. AYRTON, F.R.S., and JOHN PERRY, F.R.S., members, was read.

This paper does not resemble Prof. Hughes's inaugural address, in containing a charming account of new experimental researches into the laws of self-induction and of the extra resistance offered to a rapidly varying current; its aim is different. It is meant to help the practical electrician to obtain as clear a conception of self-induction as he now has of resistance, and to this end the paper contains the description, and theory of the action, of a simple apparatus that we devised a year ago, and which we have been since improving, for the *direct* measurement of the coefficients of self and of mutual induction in terms of the legal unit.

The electrician of to-day is so familiar with the idea of resistance, that he is liable to forget the time when people had no clear conception that the resistance of a conductor was one of its definite properties, like its weight and length. In the "Reports of the Committee on Electrical Standards," edited by the late Prof. Fleeming Jenkin, a most interesting account is given of the gradual growth of the conception that a conductor had a definite resistance; and in our paper on "A New Determination of the Ratio of the Electromagnetic to the Electrostatic Unit of Electrical Quantity," read before this society in 1879, something is said about the development of this idea of resistance. And during the 50 years that have elapsed since Lenz employed the 1 foot of No. 11 copper wire as his unit of resistance, the electrical world has not only learnt to regard resistance as a definite property of a definite piece of matter in a definite state, but has become so fully imbued with this idea, that it positively resented Prof. Hughes's experimental proof, last year, that the resistance of a conductor for an intermittent current was a variable.

Now, how has this clear perception about resistance been acquired? We believe by the measuring of hundreds of thousands of resistances during the last 22 years in terms of a unit of resistance with a simple name; and we feel that it will not be until many measurements of the coefficients of self-induction of various coils, electro-magnets, dynamos, &c., have been made by practical men, as part of their regular work, and expressed in a unit of self-induction having a simple name, that they will come to have the same instinctive feeling about self-induction that they now have about resistance. There are two reasons why such measurements have not been regularly made: one is, that the importance of a knowledge of the coefficient of self-induction of a circuit is only beginning to be generally appreciated; the other, that the methods of measuring the coefficient have not been very easy to employ. But now that the speed of telegraph signalling is becoming greater and greater, that long-distance telephony is receiving more and more attention, and that the system of distributing electrical energy with secondary generators and alternating currents has become a most important rival to other systems, the regular measurement of the coefficients of self and of mutual induction of dynamos, electro-magnets, induction coils, &c., has now become quite as important to the electrical engineer as the measurement of resistance.

Professor Hughes's telephone methods for comparing the self-induction of one circuit with that of another are marvellously sensitive, as shown by the results he obtained, but the very delicacy of the methods prevents their being used without a compensator or adjustable standard of mutual induction for the commercial measurement of a coefficient of self-induction in terms of the product of a time into a resistance.

On turning to the electrician's "stand-by," Clerk Maxwell, one finds a complete exposition of the general principles of self-induction, also several methods for determining what he calls "the Electromagnetic Capacity of Self-induction of a Coil." The very length of the name makes one fear that the methods will be impracticable for every-day work, and that is the case; for the only one which is suited to a practical man, as far as the apparatus is concerned, is unsuitable from a difficulty met with in carrying it out. The method in question is called "Comparison of the Electrostatic Capacity of a Condenser with the Electromagnetic Capacity of Self-induction of a Coil," * and the result expresses the coefficient of self-induction as equal to the product of two resistances into the capacity of a condenser. A number of attempts to employ this method were made rather more than a year ago by one of our students, Mr. Sumpner, but the necessity of having to make two separate adjustments of the resistances of the Wheatstone bridge, one in order that there should be no deflection of the galvanometer for steady currents in the arms, the other that there should be no deflection on making or breaking the battery circuit, and the fact that altering the resistances to make either of these adjustments generally disturbed the other adjustment previously made, rendered the method nearly hopeless.

If not merely the resistance of the arms of the bridge were adjustable, but also the capacity of the condenser, so that it might be made to have different known values, this method might give good results if a galvanometer with a long periodic time of vibration were employed. If, however, an ordinary bridge galvanometer were used, the difference that exists in the rate of charging of a condenser and the rate of variation of the extra current due to self-induction would make it impossible for the resistances and the capacity of the condenser to be generally adjusted so that there was no deflection of the galvanometer on making and breaking the battery circuit, for there would first be a deflection on one side of the zero, then on the other, consequently a very accurate measurement of the coefficient of self-induction could not be made. Modifications of this method, by combining resistances and one or more condensers with a differential galvanometer, have been suggested and tried with more or less good results, but, as explained later on, with none of these methods can the effect be made *cumulative*, and the test therefore very sensitive, by using the plan of rapidly making and breaking the battery circuit.

Probably the best method yet published for measuring the coefficient of self-induction in terms of the product of a time into a resistance is that described by Lord Rayleigh in his paper on "Experiments to Determine the Value of the British Association Unit of Resistance in Absolute Measure," given in the "Philosophical Transactions" for 1882, and abstracted by one of us for the Journal of the Society, where it will be found on page 152 of the volume for that year. This method, based on one devised by Clerk Maxwell, but not described in either the first or second edition of his book, consists in placing the coil with self-induction in one of the arms of a Wheatstone bridge, and first obtaining balance in the ordinary way, the battery circuit being completed *before* the galvanometer circuit, then measuring the swing of the galvanometer needle when the battery circuit is completed *after* the galvanometer circuit, and lastly measuring the steady deflection obtained when one or more of the arms of the bridge is altered by a known amount, the battery circuit being completed before the galvanometer circuit as in the first test.

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* A student might naturally conclude that, as a capacity measured *electrostatically* is of the same dimensions as a coefficient of self-induction measured *electromagnetically*, both being a simple length, it was this comparison that Clerk Maxwell referred to; but that is not the case, as shown by the working out of the problem, consequently the answer contains the square of a resistance in addition to the capacity of the condenser and the coefficient of self-induction of the coil, in fact it is not a comparison between the capacity of a condenser and a coefficient of self-induction that is actually made.

This method is simple, but it has three great disadvantages. First, while an ordinary Wheatstone bridge is employed, an ordinary dead beat Wheatstone bridge galvanometer is totally unsuitable, since on making or breaking the battery circuit, when performing the second test, the galvanometer needle must not begin to move until the extra current has ceased; and further, the time of vibration of the galvanometer needle, and the logarithmic decrement, have to be determined, as they both enter into the formula, so that in fact a ballistic galvanometer must be employed. Second, if the coefficient of self-induction to be measured be small, the swing of the galvanometer needle obtained on making or breaking the battery circuit will be very small, and cannot be accurately read. Third, in making the first test a *very accurate* balance with the Wheatstone bridge must be obtained, since the swing obtained on making the second test must be *entirely* due to the effects of self-induction. Hence, in making the first test, a sliding wire in addition to the ordinary bridge must be employed instead of the usual interpolation method of obtaining the last decimal place from the small steady deflections to the right and left of the true zero. And the effects cannot be made *cumulative* by rapidly making and breaking the battery circuit when using either this method or the one described in Clerk Maxwell, referred to above, or any simple modification of these methods, since the swings of the galvanometer needle are in opposite directions on making and on breaking the battery circuit.

A circuit containing self-induction acts as if it had a larger resistance than its true one when a current is started in it, and a smaller resistance when the current is stopped. Hence, if balance be obtained with a Wheatstone bridge in the ordinary way, the fact of any of the arms possessing self-induction, or of any one of the arms having a condenser attached to it, will produce no effect on the balance if the battery circuit be rapidly made and broken, provided that the rapidity of make and break be not too great for the currents in the arms of the bridge to reach their steady values each time that the battery circuit is made, and to die away each time that it is broken. If the currents have not time to reach their steady value when the battery circuit is closed, and to die away when it is broken, then self-induction in any one of the arms will produce a disturbance in the balance; but such a method of measuring a coefficient of self-induction would lead to very complicated formulæ, and is not worth developing with the view of obtaining a simple method of measuring self-induction.

It therefore occurred to us to consider whether, without employing such rapid makes and breaks as would prevent the currents reaching their steady values, the self-induction of a circuit might not be made to act as an apparent steady definite increase of the resistance of that circuit which could be measured in the ordinary way with a Wheatstone bridge or differential galvanometer, and by this means the measurement of a coefficient of self-induction would simply resolve itself into the measurement of a resistance and of a time. And this problem we solved in the following way, in the spring of 1886:—

The coil, the coefficient of self-induction of which it is desired to measure, is placed in one of the arms of a Wheatstone bridge, the three other arms consisting of ordinary doubly wound resistance coils possessing no appreciable self-induction, and not only is the battery circuit rapidly made and broken, but, in addition, after each closing of the battery circuit the galvanometer circuit of the bridge is either short circuited or broken, so as to cut out the galvanometer, and after each breaking of the battery circuit the galvanometer circuit is either unshort circuited or closed again, so that the galvanometer is now operative again. In this way all the successive impulses of the galvanometer needle that are produced on starting the current in the coil with self-induction produce their *cumulative* effects, but the successive impulses of the needle that, under ordinary circumstances, would be produced on the needle in the opposite direction are cut out. Hence the self-induction possessed by one of the arms causes that arm to apparently increase in resistance by a definite amount depending on the coefficient of self-induction and the number of operations performed per minute. This apparent increase of resistance produces a deflection of the galvanometer which can be noted, and its value ascertained by comparing it with the deflection produced with steady currents when one or more of the arms of the bridge is altered by a known amount, as in making the Rayleigh test. But since the necessity of having to read the deflection limits the speed of performing the double make and break operation, in order that the spot of light may not be sent off the scale, we soon replaced this comparative deflection *cumulative* method* by a much more sensitive *zero cumulative* method, and instead of reading the galvanometer deflection we re-establish the balance and bring the needle back to zero, by altering one or more of the arms of the bridge, as in making an ordinary resistance test with a Wheatstone bridge.

In our experiments we have also preferred the periodical short-circuiting of the galvanometer to breaking the galvanometer circuit, since, as there is a current flowing in the galvanometer when this operation is performed if the zero method be employed, the breaking of the galvanometer circuits would produce a spark which would make the calculations difficult, whereas, as will be seen, the periodical short-circuiting of the galvanometer produces an effect that can easily be taken into account in the mathematical investigation.

The measurement of a coefficient of self-induction in this way is extremely simple, because on condition that the periodic time of our operation is not too short for the currents to become steady in the interval between the closing of the battery circuit and the short-circuiting of the galvanometer, and to die away in the interval between the breaking of the battery circuit and the unshort-circuiting of the galvanometer, we have shown that following *remarkably simple* formula is very approximately true:

$$L = T\sigma \qquad (1)$$

where L is the coefficient of the self-induction of the coil in ohm seconds, or earth quadrants, the commercial unit of self-induction, T the time in any one operation that the galvanometer is non-short-circuited while the battery circuit is closed, and σ the apparent increase of resistance of the coil in ohms. It will be observed that, when L is small, the measured increase of resistance, σ, may be made quite large enough to be accurately measured by making T small. This may be done either by performing the operation rapidly, or, as will be seen later on, by altering the adjustment in the particular apparatus which automatically performs the required operation. *Hence this method is an extremely delicate one for the absolute measurement of a coefficient of self-induction, and the coefficient is expressed in its simplest possible form, namely, as the product of a time into a resistance.*

If, instead of periodically cutting out the galvanometer circuit while the battery circuit is being broken, we cut it out while the battery current is being made, and allow the galvanometer to be operative while the battery circuit is being broken, the resistance of the coil possessing self-induction will apparently become less by a definite amount, and in this case r will be the apparent diminution of its resistance, and T is the time the galvanometer is operative after the battery circuit is broken.

The first apparatus for enabling measurements of self-induction to be made in this way was constructed in the spring of 1886, under the superintendence of one of our assistants, Mr. Mather. It consisted of a double commutator, shown in fig. 1, the spindle, S, to which the commutators were locked by the nut, N, being rotated at any speed by a small electro-motor not shown in the figure, to which was attached a Young's speed indicator, which registered the speed of rotation at any moment. The brushes, B_1, B_2, b_1, b_2, were fixed to the baseboard and joined to the bridge, as indicated in the figure. When the double commutator was rotated by the motor (of which the speed was correctly adjusted by means of a Varley's flexible carbon resistance), the portion, A B, caused the battery circuits to be periodically made and broken, while the other portion, C D, periodically short circuited and unshort circuited the galvanometer, so that the following cycle of operations, called for simplicity *one operation*, was performed any desired number of times per minute.

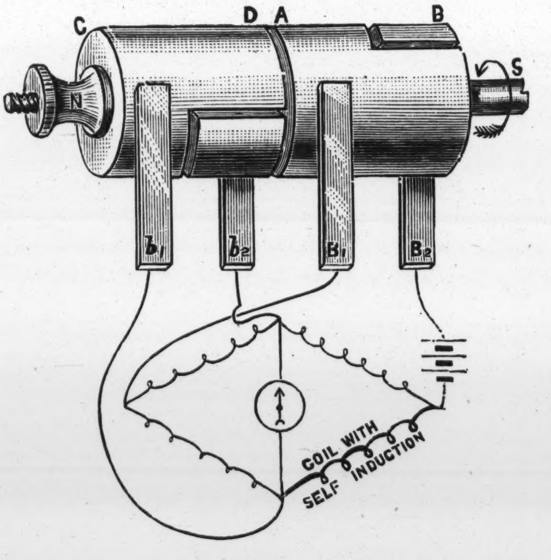

FIG. 1.

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* Since this paper was announced to be read, M. Lippmann has communicated to the French Academy a paper "Sur la détermination du coefficient du Self-Induction," by MM. P. Ledeboer and G. Maneuvrier (ELECTRICAL REVIEW, April 15th, 1887), describing a new method which these experimenters have devised. An examination of it, however, shows that it is identical with our *less sensitive* 1886 method. After giving some very accurate results that they have obtained by using the new method of testing, they say: "Nous l'avons préferée d'ailleurs aux autres méthodes pour le mésure des faibles coefficients de self-induction, et notamment à la méthode de M. H. F. Weber (modification de celle de M. Hughes), parce qu'elle conduit à une formule très simple et qu'elle nécessite, en dehors du pont du Wheatstone, d'autre disposatif expérimental qu'un interrupteur tournant."

Battery circuit.	Galvanometer short circuit.
Make.	While broken.
While made.	Make.
Break.	While made.
While broken.	Break.
Make.	While broken.

The time, T, in the formula given above is the interval that elapses in one rotation between the time when the continuous part of the commutator, A B, comes into contact with the brush, B_2, and the time when the continuous part of the commutator, C D, comes into contact with the brush, b_2. This time can be made shorter or longer by varying the speed of rotation, but it can also be varied by loosening the nut, N, and shifting one of the commutators round relatively to the other, and then screwing up the nut again. Indeed, it was for the purpose of enabling this adjustment to be easily made that double springs were in each case employed, instead of making one contact through the spindle.

At about this time, that is, in the summer of last year, we invited Mr. Sumpner, one of the third year students of the Central Institution, to experiment with this apparatus, and generally, by experimenting and by working at the subject mathematically, to find out the capabilities of this new method of measuring self-induction, also to see whether by possibly using the apparatus in some other way the method could be made even still more sensitive. We take this opportunity of thanking Mr. Sumpner for the energetic way in which he has worked at the subject, and for the very large number of experiments on the accuracy of various modes of measuring self-induction which he has conducted, with the occasional aid of two other of the third year students, Messrs. Rossiter and Watney.

The various methods of testing which Mr. Sumpner has employed, the mathematical development of the formulæ used by him in each case, and his general conclusions as to the accuracy of the various methods, are given later on in the Appendix; but one interesting result that he has arrived at may here be mentioned, viz., that although the apparatus has during the past twelve months been gradually totally altered in detail, the experiments have shown that the principle originally proposed for carrying out the measurement, requiring the cycle of operations given in the foregoing table to be periodically and rapidly performed, is the simplest and most accurate one to employ. One reason for the accuracy of the method is that neither commutator is in any one of the arms of the bridge, so that no ordinary change in the resistance of the contacts produced by oil or dust, &c., getting in between the springs and the rotatory barrels can introduce any error into the test. Of course an actual failure of contact might lead a careless experimenter to a wrong result, but so might a disconnection in the battery or galvanometer circuit in an ordinary Wheatstone bridge, if the conclusion was drawn that, because there was no deflection on pressing down the key, balance had been obtained.

The first thing to be done after constructing the apparatus, was to ascertain what was the formula connecting the unknown coefficient of self-induction with the apparent increase of resistance of the coil, and the time in which the cycle of operations was performed.

This formula we calculated ourselves, neglecting the self-induction of the galvanometer, since we felt that its effect could not be serious. Mr. Sumpner, on the other hand, took up the complete problem, and we give his proof reduced to its simplest form, since, in addition to its application to the experiment in question, the calculation is interesting in connection with the problem of measuring the capacity of a condenser with a Wheatstone's bridge and vibrating wippe, which will be found worked out by Clerk Maxwell, without, however, any notice being there taken of the self-induction of the galvanometer, the effect of which, therefore, on the answer is not considered.

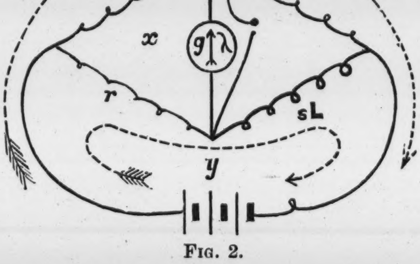

FIG. 2.

Fig. 2 shows the Wheatstone bridge, s being the resistance of a coil with a coefficient of self-induction L; p, q, and r are the resistances of the three other arms of the bridge when they are so adjusted that there is no deflection of the galvanometer on rotating the commutators at a certain speed. On rotating the commutators, a current will sometimes pass one way through the galvanometer, and sometimes the other, but with the particular speed of rotation, p, q, and r are such that the total quantity passing through the galvanometer is nought. The resistance and coefficient of self-induction of the galvanometer are g and λ, and the electromotive force and resistance of the battery E and b. Then if x, y, z be the imaginary currents on the meshes,*

$$r\,(x - y) + p\,(x + z) + g\,x + \lambda\,\frac{d\,x}{d\,t} = 0$$

$$b\,(y + z) + r\,(y - x) + s\,y + L\,\frac{d\,y}{d\,t} = E$$

$$b\,(y + z) + p\,x \qquad + q\,z \qquad = E$$

Eliminating y and z, we have

$$A\,x + B\,\frac{d\,x}{d\,t} + P\,\frac{d^2\,x}{d\,t^2} + C \quad = 0 \qquad (2)$$

where $A = \begin{vmatrix} r + p + g & -r & p \\ -r & s + b + r & b \\ p & b & p + q + b \end{vmatrix}$

$$B = \lambda \begin{vmatrix} s + b + r & b \\ b & p + q + b \end{vmatrix} + L \begin{vmatrix} p + g + r & p \\ p & p + q + b \end{vmatrix}$$

$$P = (p + q + b)\,L\,\lambda,$$

$$C = E\,(p\,s - q\,r).$$

Integrating (2) we obtain

$$A\int x\,d\,t + B\int d\,x + P\int \frac{d^2\,x}{d\,t^2}\,d\,t + \int C\,d\,t = 0 \qquad (3)$$

The effect on the galvanometer needle may be divided into two parts—one, the first rush of electricity that occurs through it when the battery circuit is closed during the time the galvanometer is not short-circuited, and the diminution of this current through zero and its increase in the opposite direction until it reaches a certain definite value, when the currents in the arms of the bridge have become steady; the second, the dying away of this reverse current in the galvanometer while it is short-circuited. These two effects we shall consider separately.

To ascertain the amount of the first effect, we must integrate between t equals nought and t equals T, since, by hypothesis, T is the interval that elapses between the closing of the battery circuit and the short-circuiting of the galvanometer.

Integrating between these limits we have

$$\int_0^T x\,d\,t = Q_1,$$

where Q_1 is the quantity of electricity that flows through the galvanometer in the time T,

$$\int_0^T d\,x = -\,\frac{C}{A},$$

since this is the final steady value of the current, x, which nought at time nought.

Also $$\int \frac{d^2\,x}{d\,t^2}\,d\,t = \frac{d\,x}{d\,t}$$

and $$\frac{d\,x}{d\,t} = 0 \text{ at time T},$$

since, by hypothesis, T is long enough for the currents to become steady. To find the value of $\frac{d\,x}{d\,t}$ at time nought, we have the fundamental differential equation for the current through the galvanometer

$$g\,x + \lambda\,\frac{d\,x}{d\,t} = V,$$

where V is the potential difference at the terminals of the galvanometer at any time. And since where t equals nought x equals nought, we have at time nought

$$\frac{d\,x}{d\,t} = \frac{V_0}{\lambda},$$

where V_0 is the value of the potential differential at the terminals of the galvanometer at time nought

and $$V_0 = -\,\frac{E\,p}{p + q + b},$$

since at time nought both x and y are nought, therefore at time nought

$$\frac{d\,x}{d\,t} = -\,\frac{E\,p}{\lambda\,(p + q + b)},$$

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* For the method of solving such problems by the employment of these imaginary currents, see a most interesting paper by Dr. Fleming in the proceedings of the Physical Society, Vol. VII., p. 215.

and therefore $\int_0^{T} \frac{d^2 x}{d t^2} d t = - \frac{E p}{\lambda (p + q + b)}$.

Lastly

$$\int_0^{T} d t = T,$$

therefore equation (3) reduces to

$$A Q_1 - B \frac{C}{A} + P \frac{E p}{p + q + b} + C T = 0.$$

Next let us consider the dying away of the current in the galvanometer after it is short circuited. We may now use simply the equation

$$g x + \lambda \frac{d x}{d t} = 0,$$

if the resistance of the short circuit be very small compared with that of the galvanometer itself.

Multiplying by $d t$, and integrating from t equal T to t equal T^1, say, the time the short circuit is removed, we have

$$g Q_2 + \lambda \int d x = 0,$$

where Q_2 is the quantity of electricity that passes through the galvanometer while short-circuited. At the moment after short-circuiting

$$x = - \frac{C}{A}$$

the steady value of the current, since the self-induction of the galvanometer prevents any instantaneous change in the current passing through it, and at t equals T^1 the current in the galvanometer is nought, since, by hypothesis, the time of short-circuiting $T^1 - T$ is long enough for the current in the galvanometer to die away,

$$\therefore \int_{T}^{T^1} d x = - \left(- \frac{C}{A} \right).$$

Now in order that there may be no deflection of the galvanometer, we must have

$$Q_1 + Q_2 = 0,$$

$$\therefore \frac{B C}{A_2} - \frac{P}{A} \frac{E p}{\lambda (p + q + b)} - \frac{C}{A} T = \frac{\lambda}{g} . \frac{C}{A} \qquad (3).$$

Let σ be the apparent steady increase of the resistance of the coil with self induction (of which the ordinary resistance is s) produced by the rotation of the commutator at speed corresponding with the times T and T^1, then

$$p (s + \sigma) = r q,$$

$$\therefore C = - E p \sigma.$$

Substituting this value for C, and for P its value $L \lambda (p + q + b)$ in equation (3), we have

$$L = \sigma \left(T + \frac{\lambda}{g} - \frac{B}{A} \right) \qquad (4).$$

Now $\frac{\lambda}{g}$ and $\frac{B}{A}$ are usually small compared with T, therefore when this is the case

$$L = \sigma T,$$

the simple formula previously referred to.

Referring to fig. 1, it will be seen if the brushes B_2 and b_2 touch over a small area, and if the centres of these areas are in a plane passing through the axis of rotation, that T is simply equal to

$$\frac{\text{angle between the slits in the two commutators}}{360° \times \text{number of revolutions per second.}}$$

We may call

$$\frac{\text{angle between the slits in the two commutators}}{360°}$$

the lead or l, and l will be equal to $\frac{1}{4}$, for example, when each of the cycle of operations given in the table lasts for one quarter of a revolution.

Introducing l we have, if σ be in ohms.

$$L = \frac{l}{n} \sigma \text{ second-ohms},$$

where n is the number of revolutions of the commutator per second, or

$$L = \frac{60 \, l \, \sigma}{N} \text{ second-ohms} \qquad (5).$$

where N is the number of revolutions per minute.

A large number of experiments were made in May, 1886, with a solenoid of which the resistance was about four ohms at ordinary temperatures, to see how nearly the coefficient of self-induction determined by using the commutator arrangement running at different speeds, and with different leads, agreed with the coefficient of self-induction determined by Lord Rayleigh's method, which gave 0·0215 second-ohm for the solenoid alone, and 0·517 second-ohm when a certain iron core was introduced into the solenoid.

The following are some of the results obtained with the solenoid without the iron core when the lead

$$l = \tfrac{1}{12} \text{ about:—}$$

N	$s + \sigma$	σ	$L = \frac{60 \, l}{N} \sigma$
0	4·06		
660	6·70	2·64	0·0200
760	7·00	2·94	
860	7·50	3·44	0·0200
997	8·00	3·94	
1117	8·50	4·44	
1240	9·00	4·94	
1362	9·50	5·44	0·0200
1450	11·00	6·94	
1850	12·00	7·94	0·0204
2335	13·50	9·44	0·0202

Plotting these results on squared paper, we obtain the curve, A A A (fig. 3), the abscissæ representing the values of N, the number of revolutions per minute, and the ordinates the values of $s + \sigma$, the apparent resistances of the solenoid at the various speeds. This curve we see is a perfectly straight line, which means that the increase of resistance is proportional to the speed; or, in other words, the approximate formula (5) for calculating L may be employed with *any* of the results, and the value of L so obtained from a few of the results is given in the last column of the preceding table. That we may use the approximate formula at all for L shows us that the term

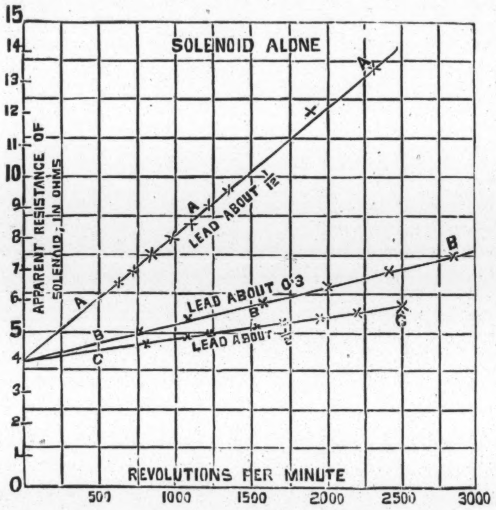

FIG. 3.

$$\frac{\lambda}{g} - \frac{B}{A}$$

in the expression (4) is negligible in comparison with T; and that we may use it even for the result obtained with the highest speed of rotation employed, viz., 2,335 revolutions per minute, shows us that $\frac{1}{12 \times 2335}$ minute, or about 0·0022 of a second, which is the time the galvanometer remains unshort-circuited after the battery circuit is closed, is long enough for the currents in the bridge to reach their steady value.

The values of the coefficient of self-induction obtained, 0·020, are appproximately equal to 0·0215 second-ohm, the value obtained by Lord Rayleigh's method, and that they are not exactly the same arises from the difficulty, already referred to, of estimating the lead l accurately with the eye. This would not introduce any inaccuracy in the actual use of the instruments, since for a given adjustment of the relative positions of the commutators, AB, and CD, in fig. 1, the value of l is a constant, and this value would be determined once for all, not by the eye, but by an actual experiment made with a coil of known self-induction. We were not, however, calibrating the instrument on the assumption that the approximate formula (5) was true, but using the instrument to see how nearly (5) might be employed. In our experiment l was probably not $\frac{1}{12}$ exactly, but more nearly $\frac{1}{11}$.

(To be continued.)

NEW PATENTS—1887.

5798. "Moulding the impressions of electrotypes." J. Caprani. Dated April 21.

5833. "Combined gas motor engine and dynamo-electric machine." F. W. Crossley. Dated April 21.

5835. "Contact makers." D. L. Selby-Bigge. Dated April 21.

5862. "Simultaneously driving a number of clocks by magneto-electricity." W. Blenheim. Dated April 22.

5867. "Secondary batteries." W. Kingsland. Dated April 22.

5949. "Posts, pillars, and pedestals for use with electric lamps." F. R. Fairbairn. Dated April 23.

5955. "Making thermo-electric elements or chains." G. E. Dorman. Dated April 23.

5958. "Dynamo-electric and magneto-electric machines." A. M. Clarke. (Communicated by L. Maiche.) Dated April 23.

5972. "Attaching telegraphic, &c., insulators to bolts, spikes &c. A. Johnston. Dated April 25.

6059. "Binding devices for electric conductors." A. G. Brookes. (Communicated by J. F. Haskins.) Dated April 26.

6086. "Electro-deposition." S. P. Thompson. Dated April 26.

6104. "Electrical measuring instruments." A. Le N. Foster, F. V. Andersen. Dated April 26.

6160. "Electric inductive translators or transformers; regulating them." W. Main. Dated April 27. (*Complete.*)

6168. "Checking payment for the use of telephones." H. F. Jackson. Dated April 27.

6177. "Adapting electric lamps to helmets of divers." A. Marcilhacy. Dated April 27.

6201. "Electric meters." R. Dick, R. Kennedy. Dated April 28.

6204. "Induction coils and transformers." W. J. Muller. Dated April 28.

6219. "Induction apparatus and the use of it in studying dynamo-electric machines." J. Swinburne. Dated April 28.

6221. "Regulating feed of arc lamp by electro-chemical action." A. Shippey, W. J. L. Hamilton. Dated April 28.

6267. "Lock switches for use in electric circuits." A. E. Cockburn, E. Thomas. Dated April 29.

6273. "Porous plates and cells for electrical batteries." J. T. Armstrong. Dated April 29.

6294. "Electrolytic treatment of zinc and its ores." A. Watt. Dated April 29.

6363. "Central telephone stations or exchanges." G. F. Redfern. (Communicated by G. Lagache.) Dated April 30. (*Complete.*)

6400. "Electro-magnetic apparatus for automatic lighting and extinguishing of gas lamps." J. R. Schiller, C. Meyer. Dated May 2.

6409. "Dynamo-electric machines." R. E. B. Crompton, W. A. Kyle. Dated May 2.

6581. "Holders for electric lamps." E. Manville, W. L. Madgen. Dated May 4.

CORRESPONDENCE.

Electric Locomotion.

In your leading article on the above subject, you make a point of enquiring the running costs of the Mumbles-Swansea Railway, and you quote the remark of Sir John Jenkins as made at the Society of Arts, viz., that the cost of haulage per train mile on the Swansea line did not exceed one-half that stated by me in my paper. I gave detailed working costs of several electric tramways, the Frankfort-Offenbach line, for instance, on which nearly a million passengers were carried last year and close upon 300,000 miles run in the same period. The expenses, exclusive of wages and salaries, came to 1·6 pence per mile, but the wages and salaries item amounted to 2·23 pence per car mile, or more than 58 per cent. of the entire expenses. If Sir John Jenkins includes the wages of driver, stoker, conductor, directors' fees and management salaries, furthermore the cost of repairs of engines, cars and roadway, as included in the example I gave, we shall probably find that the Swansea railway is even less economical than any one of those enumerated in my paper before the Society of Arts.

A. Reckenzaun.

Single Needle Duplexing.

Referring to your publication of the 29th ult. I note with pleasure that the telegraph superintendent of the Caledonian Company has by his letter wisely cooled down and abandoned the main point at issue, and told us that his difficulty in duplexing single needles is to be further complicated by the addition, and consequent shutting out of more intermediate stations. I am content to leave this further *new departure* to the judgment of the practical. I have since observed with surprise that this ancient system of single needle duplexing carries with it a patent in the name of J. Fleming, another employé of the Caledonian Company, dated after my published remonstrance against the originality of the same, and I now desire to state through the medium of your columns that there cannot possibly be anything new, *or any new departure*, when it is so well known that the very same arrangement was introduced by me and worked on the North British Railway some 14 years ago. Permit me to ask you to correct a little mistake in my letter of the 22nd ult., viz., in the last line the word *expect* should have been *repeat*.

Arthur E. Gilbert.

May 3rd, 1887.

"Mixed."

What is the matter with the electric lighting at the Prince of Wales' Theatre? I paid "Dorothy" a visit the other evening and found every available gas burner in the auditorium shooting forth the usual flame, accompanied by the indispensable vitiated air; on descent of the act drop, the electric lamps were switched on, giving a nice mellow light, almost sufficient to read a programme by, each lamp contributing at least 4 C.P.; I believe they are nominally 16 C.P. lamps.

This may account for the 2,500 hours' life as given in the report which appeared in your paper the early part of this year; if still run at this great brilliancy, they may very easily complete 7 or 8,000 hours, which will be a lasting advertisement of longevity for Edison and Swan.

I also noticed Argand burners in the footlights, and the Welsbach in all the saloons and smoking foyer.

The various methods of lighting this pretty theatre are so curiously "mixed," the casual observer wonders why oil lamps, candles, and night-lights should not be added to make the general illuminations complete.

Who is to blame, the attendant for not looking after the plant, &c., or the management?

It would be very interesting to see the amounts paid for gas when next year's report on the "Electric Lighting" (?) of this theatre appears.

With apologies for trespassing on your valuable space,

Troubadour.

Parchment Paper Cells.

I shall be much obliged if some of your readers can tell me where I can get parchment paper cells for Daniell cells; also what glue is the best to fix them together. I have tried marine glue, which soon cracks and lets the edges part.

Amateur.

Gas Lighting by Electricity.

In your issue of this date you illustrate and describe various electric gas lighting appliances as introduced by Messrs. Woodhouse and Rawson. These are by no means novel, as the same apparatus have been illustrated and described in our catalogue and sold by us for several pears, and have been sold in America for at least ten years. You also mention Mr. Lane-Fox's appliances as used for some time time at Pall Mall, a most ingenious system in which the writer assisted.

Henry J. Dale.

April 29th, 1887.

Secondary Generators or Transformers.

We have read with great interest the series of articles by Mr. Rankin Kennedy published in your valuable paper and will venture to make some remarks about it.

We, of course, cannot pretend to know the intimate thoughts Mr. Kennedy had in 1883; he may already have had at that time clear ideas about the closed magnetic circuit and about the parallel distribution with transformers; but, strangely enough, you will find by reference to the sketch published in your issue of June 16th, 1883, that the induction coil in form of a Gramme ring experimented upon in 1883 by Mr. Kennedy was a two poled one, and not a representant of the closed magnetic circuit principle, as it would appear to your readers after the perusal of the latest publications of the same author.

As to the parallel transformer system, we were the first to emphatically give publicity to its fitness for general distribution of electricity, and we put it to a practical use on a large scale at the Budapest National Exhibition in April, 1885. Nearly 2,000 lamps of 56 volts, at a mean distance of three-quarters of a mile from the generators, were supplied by about a dozen transformers; the primary tension amounted to 1,350 volts. There were Cardew voltmeters with special transformers for reducing the high tension for them; also return test wires from the low tension circuits to the generating station, self-regulation of the generators and, of course, of the transformers, in fact, nearly all the "latest improvements" since suggested. This plant was in daily work till November 1885, and a large number of professional men from all parts of the world were shown over all the details of it.

We hope the above cited facts will contribute to clear up ideas about the history of the parallel transformer system and some of the points connected with it.

Ch. Zipernowski,
Max Deri,
Otto T. Blathy.

April 28th, 1887.

The Practice of Dynamo Design.

As I have not seen Mr. Fricker's article I am unable to criticise it. The following formula, however, which I have recently been using, seems to be more simple than the one published in the ELECTRICAL REVIEW some weeks back.

We have the formula:—

$$\mathrm{F} = \frac{z\,\mathrm{A}\,\mathrm{N}\,n}{10^6}$$

where:—

E = E.M.F. generated in the armature,
z = number of Kapp lines per square inch,
A = sectional area of both sides of the armature,
N = number of copper conductors counted all round the armature,
n = number of revolutions per minute,

$$\therefore \mathrm{A} = \frac{\mathrm{E} \times 10^6}{z\,\mathrm{N}\,n}$$

Also $\mathrm{A} = (\mathrm{D} - d)\,l$

where D = external diameter of the armature core.
d = internal " " "
l = length of armature core.

We must now decide what ratio D, d and l must bear to one another.

Let $d = \alpha\,\mathrm{D}$
And $l = \beta\,\mathrm{D}$
Then $\mathrm{A} = (\mathrm{D} - \alpha\,\mathrm{D})\,\beta\,\mathrm{D}$
$= \beta\,\mathrm{D}^2\,(1 - \alpha)$

Let x = number of conductors per inch of peripery of armature core,
Then $\mathrm{N} = \pi\,\mathrm{D}\,x$.

Substituting we get

$$\beta\,\mathrm{D}^2\,(1 - \alpha) = \frac{\mathrm{E} \times 10^6}{z\,\pi\,\mathrm{D}\,x\,n}$$

$$\therefore \mathrm{D}^3 = \frac{\mathrm{E} \times 10^6}{z\,\pi\,x\,n\,\beta\,(1 - \alpha)}$$

$$\therefore \mathrm{D} = 100\,\sqrt[3]{\frac{\mathrm{E}}{z\,\pi\,x\,n\,\beta\,(1 - \alpha)}}.$$

This formula applies to both Gramme and Drum armatures.

E. J. F.

May 2nd, 1887.

Pollak and Binswanger's Tramway.

It is interesting to learn from your illustrations and description of the "magnetic" system of tramway propulsion advocated by Messrs. Pollak and Binswanger, that they have advanced further in its development than the diagram exhibited at the Society of Arts, when Mr. Reckenzaun read his admirable paper, would lead anyone who had studied the subject to suppose; far enough, one would think, for them to admit the correctness of the statement I then made, viz., that a line constructed in accordance with that diagram would not work successfully.

It is to be regretted that my remarks should be taken as unfavourable to the system when I consider it a promising one, but like everything else, largely dependent upon the design of its various details and the care with which they are carried out.

M. Holroyd Smith.

May 4th, 1887.

Telephone Relays.

In your issue for December 10th, 1886, I observe an article under the above heading, in which it is stated that telephone relays are worse than useless. That is perfectly true if, as assumed, they are constructed on the same lines as a telegraph relay. But I have designed a relay in which the relaying current does not replace the original current, but is merely added to it. The arrangement is as follows:—The current passes through the magnet coil of a receiver, and also through the secondary coil of a transmitter, in the primary circuit of which is placed the ordinary battery cell, and the two instruments are so placed as to have one diaphragm common to both. Of course the coils must be so connected that the currents induced in the secondary coil do not oppose the original current.

My own opinion is, however, that the difficulty in speaking over long distances is not caused by leakage or resistance, but by self-induction and mutual induction, and in many cases, of course, by induction from external sources.

C. G. McEwen.

Harrismith, Orange Free State,
April 4th, 1887.

Sparking in Telegraph Relays.

In reference to Mr. Clark Fisher's comments upon my paper of the above title, although his apparatus performs a very different function from that of a translating relay, yet the conditions would appear very favourable for the short-circuiting of the battery. If it would not be troubling Mr. Fisher too much, might I ask what means he employs to prevent such an occurrence? It would also be interesting to know the purpose for which his apparatus is used.

W. Moon.

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